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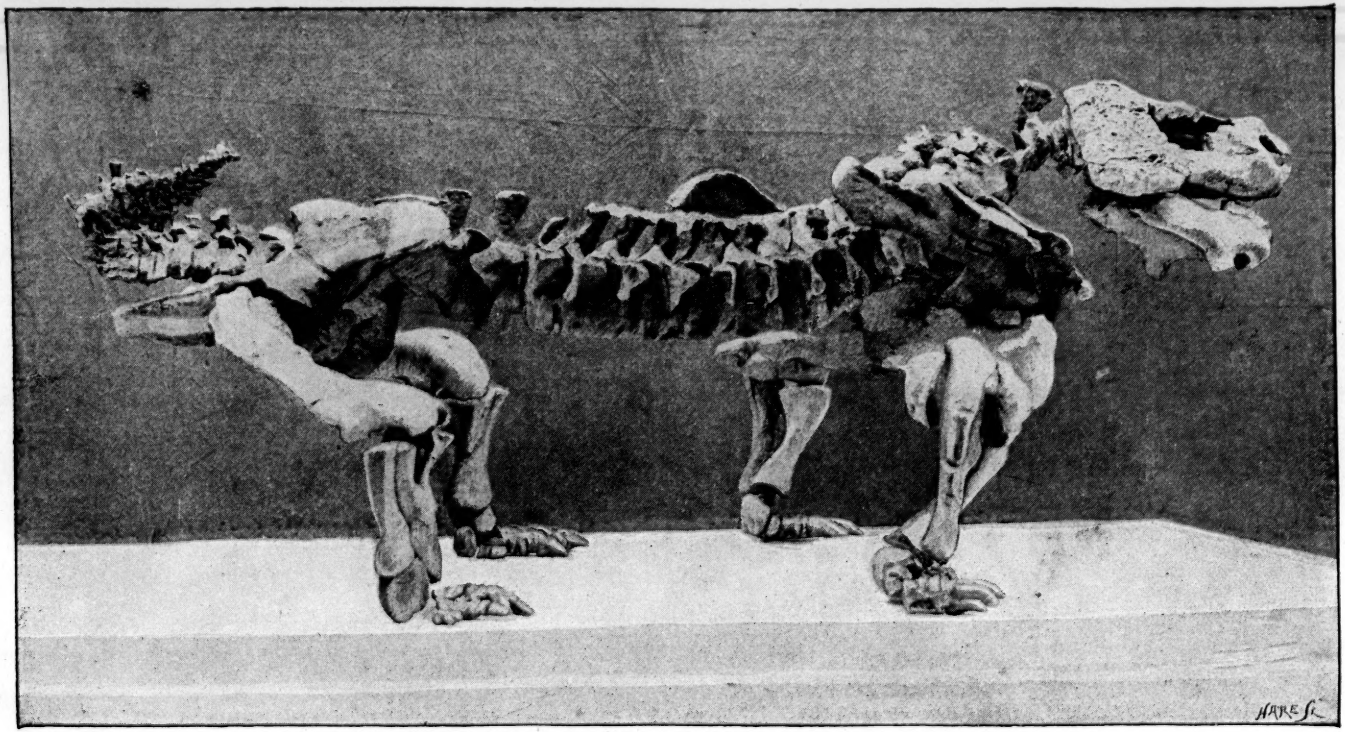


Skeleton of *Pareiasaurus Baini*, Seeley.

Karoo Formation (Trias), Bad, near Tamboer Fontein, Cape Colony.

The original preserved in the British Museum (Natural History). Length of skeleton 7 feet 9 inches.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. II.

No. I.—JANUARY, 1895.

I.—Note on the Skeleton of *Pareiasaurus Baini*.

By Prof. H. G. Seeley, F.R.S., F.L.S., F.G.S.

(PLATE I.)

THE skeleton of *Pareiasaurus Baini*, which I brought from the Bath near Tamboer Fontein, in Cape Colony, is shown in the accompanying photograph of the right side of the specimen, as it is now mounted in the British Museum. It is the only known example of the group of animals to which it belongs, in which almost every part of the skeleton is shown. The Dicynodonts were familiar to us from the discovery of many skulls; the Theriodonts were mostly known from snouts; and the *Pareiasaurus*, although originally described from skull remains, had become known from the fine axial skeleton of *P. bombideus*, which Mr. Thomas Bain sent to the British Museum many years ago. I therefore entertained hope that the limbs and other missing parts of the skeleton might reward personal exploration in the country. The area to be examined was clearly defined as lying approximately between the Prince Albert Road Station and Fraserberg; for Dr. W. G. Atherstone had found the type of the species near the former locality, and Mr. Bain had found the specimen described by myself in 1887–8 at Palmiet Fontein, at the foot of the Nieuwveldt Range, towards the latter place.

The southern position, within easier access of the railway, offered the best hope of success, since a few farmers are scattered over the country, and there was hope that their Hottentot shepherds might have observed bones lying upon the surface of the ground; though such remains only occur in small oases among immense unproductive or desert areas. Between the Zwarteberg, on the south, and the Nieuwveldt Range on the north, the country is generally level, or but slightly undulating. At Bad the rocks become folded and more elevated; and there, by the kindly offices of Mr. J. S. Marais, and accompanied by the late Mr. Thomas Bain, I first saw the fossil dimly outlined in the hard concretionary and slaty rock, some distance up on the hill, on the 11th August, 1889, and at once determined it as the *Pareiasaurus* for which I was systematically searching. The specimen had obvious defects, due to partial exposure, the compression of some of the limb bones, and the friable condition of parts which had long been under the expanding influence of the sun. On the following day I had the pleasure of

removing the remains, with the aid of my friends, from the mountain side. It was my share of the task to direct and control the quarrying operations of ten men, all through the day, to identify every part of the skeleton as it was successively exposed, so as to prevent the picks from destroying it as soon as it was touched; to mark with vermilion colour every isolated block as it was broken away from the remains, so as to have hope that they would some day be joined together again; and finally to direct the carrying of the blocks down to the boxes in the waggon which was waiting to receive them in the valley below, so as to insure that pieces which were associated should not be widely separated from each other. With the exception of Mr. Marais and Mr. Thomas Bain, I had never previously met any of the men who shared with me the labour of getting the fossil away. After many accidents, resulting from its weight being greater than the boxes obtainable were able to endure, the fossil reached the British Museum, an unprepossessing heap of rock, among which were some indications of bones.

During three months I built those fragments together, so as to restore the remains to the aspect which they presented on the mountain side on that 12th of August. And then the rock was gradually removed by Mr. Richard Hall, under my constant supervision, extending over the greater part of two years. The bones were retained in the positions in which they were found at first, till it became manifest that, by partially separating them, they might be articulated with each other. Thus a partial restoration of the form of the skeleton has been made, without attempting to restore the vertebral column to its original curvature. To this Mr. Caleb Barlow has contributed in moulding the forms of some bones on the left side, now tinted a paler colour, which were not found.

At present it would be premature to say anything concerning this animal as a contribution to the stores of knowledge of animal structure in comparative anatomy. It admits of being compared with the known groups of reptiles recent and fossil as well as with mammals. Hereafter the value of these comparisons will become evident when the fossil allies of the *Pareiasaurus* take their places by its side. Its true affinities are to a great extent masked under superficial characteristics, such as are seen in the pitted armour which roofs over the skull, in a way which parallels the labyrinthodont type, so as to show that Labyrinthodonts more closely approach reptiles than had been previously demonstrable. The single occipital condyle, even though it is almost as concave as in a Teleostian fish, leaves no doubt that the animal finds its place among true reptilia. But no animal previously known has shown such a multitude of sharp recurved teeth on the palate, coupled with teeth in sockets in the alveolar margins of the jaw; which are like those of the marine lizard *Amblyrhynchus* in general type, though the number of denticles is greater, and the successional teeth appear to be arranged uniformly in the mandible below the series in use. The most singular structure of the palate is the lateral truncation of what are probably the

transverse bones, so that those bones extend between the rami of the mandible. Notwithstanding the extremely heavy build of the animal, there is much that recalls mammals in the characters of the pelvis, the shoulder-girdle, and the fore and hind limbs; so that the fossil stands alone at present in its approximation in these regions of the skeleton to the highest vertebrata, though it is the shoulder-girdle chiefly which fixes its affinity with the Monotremata. The new knowledge of the reptilian skeleton which this animal supplies gives a meaning to the term Ordinal Anomodontia, by showing resemblances in the teeth to various groups of animals which could never have been suspected from the reptilian structure of the skull, or the mammalian structure of the extremities.

It has been a pleasure to contribute a fossil which has made this animal type more intelligible; but it is no less a pleasure to acknowledge that everything has been done by Dr. Henry Woodward to secure that the specimen should receive the best treatment possible, both before and after it was presented to the National Collection.

II.—A Criticism of the Astronomical Theory of the Ice Age, and of Lord Kelvin's Suggestions in connection with a Genial Age at the Pole.

By Edward P. Culverwell, M.A., Fellow of Trinity College, Dublin.

(Part I.)

WHILE the favourable reception which the Astronomical Theory of the Ice Age has met with among scientific men has been chiefly due to the writings of Dr. Croll, its more general acceptance, especially among the semi-scientific public, has been greatly assisted by the lucid and vigorous exposition by Sir Robert Ball, in his "Cause of an Ice Age," published in 1891. But notwithstanding the apparently exhaustive way in which Croll discusses the problem, and the fact that Sir Robert Ball's work has been published in the "Modern Science" Series (indicating that the theory has secured a place among the permanent acquisitions of science), I venture to think that a careful examination of the problem will show that the theory is but a vague speculation; clothed, indeed, with a delusive semblance of severe numerical accuracy, but having no foundation in physical fact, and built up of parts which do not dovetail one into the other. The following pages contain what I hope will be admitted to be a justification of this sweeping condemnation. The first portion of my paper deals with Croll's form of the theory; the second, to be published next month, deals with Sir Robert Ball's form.

Part I. Examination of Croll's "Climate and Time."

Of the 527 pages of which the body of this work consists, only a few are occupied with the *direct* effects of the theory, somewhat more with the indirect effects, over 150 pages with the theory of oceanic circulation, upwards of 200 pages with the geological record, the age of the sun, and glacier motion. Practically, the exposition of the theory is contained in the four following chapters:—

Chap. IV. Outline of the Physical Agencies which lead to Secular Changes in Climate (pp. 54–80).

Chap. XIV. Five pages of this chapter on The Wind Theory of Oceanic Circulation in relation to Changes of Climate (pp. 226–235).

Chap. XIX. Geological Time—Probable Date of the Glacial Epoch (pp. 311–328); and

Chap. XXV. The Influence of the Obliquity of the Ecliptic on Climate, and on the Level of the Sea (pp. 398–419).

There are two other Chapters, XXIII. and XXIV. (pp. 368–397), on "The Physical Causes of the Submergence and Emergence of the Land during the Glacial epoch," which may, perhaps, be considered to be more or less closely related to the astronomical theory, but, as they are quite independent of the *origin* of the glaciation, I have not included them, nor do I intend to discuss them here, neither do I intend here to discuss the position taken up by Dr. Croll in dealing with the obliquity of the ecliptic. I have given a short criticism of it in a paper which appeared in the Phil. Mag. of December, 1894.

I.—Statement of Croll's Position.

Croll's reasoning consists of a chain of arguments, and care is necessary to distinguish them one from the other. In his view the direct effect of the astronomical cause is to lower the terrestrial temperature considerably; this lowering sets up other agencies, the indirect ones, and these operate chiefly to produce an Ice Age. In other words, Croll sets himself to answer three questions:—

1. What was the direct effect of the increase in eccentricity upon the climatic and physical condition of the earth?

2. How did this direct effect set up the indirect agencies?

3. How did these indirect agencies operate to produce a Glacial epoch?

As Croll has nowhere classified the causes he assigns in relation to these questions, I will now endeavour to exhibit each in its proper place.

Croll's Answer to Question 1.

His answer to this question resolves itself into a chain of five links, denoted here by A, B, C, D, E, and F.

(A) In a period of great eccentricity, the hemisphere which has its winter in the part of the orbit remote from the sun will have a long winter and a short summer, the greatest length of the winter being 199 days as against our 179 days, and the least length of summer being 166 days as against our 186 days (Croll, p. 57).

(B) Owing to the greater distance of the sun in this long winter much less daily sun-heat will be received in the long winter on any latitude than is now received in an equal time on the same latitude; on midwinter day the decrease will be about 16 *per cent.* of the present amount (pp. 55–57, 323).

Hence—

(C) The winter temperature, as far as directly affected by sun-

heat, will be reduced by an amount which may be estimated thus:—But for the sun-heat the earth would fall to nearly the absolute zero of temperature—say, to be on the safe side, it would fall to — 239° F. (Pouillet's temperature of space). Thus in mid-winter the temperature of Great Britain (about 40° F.) is kept by the sun-heat about 280° F. above what we may call its *natural zero.* Hence, roughly speaking, the decrease of 16 per cent. in the mid-winter intensity of sun-heat will lower the *excess* of midwinter temperature above the temperature of space by a *proportionate* amount, *i.e.* by 45° F. (pp. 35, 37, 323).

(D) The effect of this lowering of temperature, combined with the great length of the winter, will be to increase greatly the amount of the snow-fall. In his "Discussions on Climate and Cosmology," he says that "a simple lowering of temperature such as would secure that snow instead of rain should fall for six or eight months in the year would suffice," and adds that this would follow as a direct result of the increase in eccentricity ("Climate and Time," pp. 57, 58; "Cosmology," p. 53).

(E) Although the summer sun-heat will be increased just as much as the winter sun-heat is diminished, it will be unable to melt the additional snow, and the summers will actually be colder, notwithstanding the increased sun-heat. Thus from year to year there will be an accumulation of ice, which will tend to produce on the northern hemisphere a state of glaciation (pp. 58–66, 69, 324). On p. 67, discussing Mr. Murphy's views, Croll says: "It is not correct to say that the perihelion summers of the Glacial period must have been hot. There are physical reasons, as we have just seen, which go to prove, notwithstanding the nearness of the sun at that season, the temperature would seldom, if ever, rise above the freezing-point." The physical reasons he refers to will be given in full in the criticism of this argument.

(F) As the increase of eccentricity tends to produce a state of glaciation in the hemisphere whose winters are in aphelion, so "exactly opposite effects take place in the other hemisphere, which has its winter in perihelion. There the shortness of the winters, and the highness of the temperature, owing to the sun's nearness, combine to prevent the accumulation of snow" (p. 69; repeated on p. 402).

This is a fair outline of the direct effects of the increased eccentricity on climate, as urged by Croll. We must now give his answer to the question, what indirect agency is set up by this direct effect?

His Answer to Question 2.

(G). The direct tendency of the eccentricity when the northern winters are in aphelion, and the southern in perihelion, being to produce a state of glaciation in the northern hemisphere and a genial state in the southern, the *median* line between the trade winds will be shifted very much to the south, and the great equatorial currents of the globe would be entirely changed. The Gulf Stream would

be stopped, and the warm water of the tropics, instead of being carried to northern latitudes, would be sent southwards (pp. 69–71).

(H) Another effect which Croll seems to classify under the indirect agencies is, that the great heat of the summer in the tropical regions would give rise to great evaporation, which would be carried up by the aerial currents, and at last fall in snow on the ice-covered regions of the north, where, he says, the greatest snow-fall would take place in summer.

His Answer to Question 3.

The answer to the third question is now easy. Dr. Croll has been at much pains to show how greatly temperatures in northern regions depend on the enormous amount of heat transferred by the Gulf Stream and other ocean currents, so that the stoppage of these currents completes the work begun by the previous agencies, and thus accounts for the vast amount of glaciation observed.

II.—Criticism of Croll.

I now take each cause in detail and examine it.

(A) This is undoubtedly the case.

(B) Of course there is such an effect, but Croll does not seem to have observed that at *midwinter* the effect of the greater distance of the sun in diminishing the supply of heat *is entirely confined to those regions of the earth on which the sun shines*, so that it is *scarcely felt in the Arctic regions*, and it is chiefly felt in the southern tropics, where, the heat received by solar radiation being greatest, the percentage decrease is also greatest. In fact, the only difference at the North Pole is, that while it is now only 179 days without any sun-heat, it will in the time of greatest eccentricity be 199 days in the same condition. But, since the lowest temperature appears to occur in January, it seems unlikely that the slightly longer absence of the sun would make much difference.

(C) This is really the fundamental argument on which the whole theory hinges. It is quite inconsistent with another statement of Croll's, regarded by him as almost equally important, that the influence of ocean streams in raising our winter temperature is extremely great. For, if the winter temperature be so greatly due to ocean currents and not to sun-heat, what can be more improper than to treat the winter temperature as wholly due to winter sun-heat when we are getting the reduction of winter temperature due to reduction of winter sun-heat? Yet this is what Croll does. He gets the enormous reduction of 45° in midwinter temperature on the ground that the reduction of midwinter excess of temperature over — 239° F. in Great Britain must be in proportion to the reduction of sun-heat; and then he tells us that so vast is the effect of the Gulf Stream on the temperature of Great Britain that a *further* great lowering of temperature must follow its removal. Here Dr. Croll seems to have forgotten the homely proverb that you cannot eat your cake and have it. Evidently he should have estimated the proportion which the winter heat

received from the Gulf Stream bears to the winter sun-heat, and then he could have estimated the percentage reduction in the *whole* heat supply due to the known reduction in *sun* heat. In addition to this, it was quite out of date for him to take a *proportionate* reduction at all. Even when the first edition of "Climate and Time" was published, physicists knew that the reduction was far less, and four years before the second edition was published, the law of the 4th power, used later on in this article to show how Dr. Croll might have worked the problem, had been published by Stefan. But Dr. Croll was content to found his theory on an assumption of Herschel in his "Outlines of Astronomy," § 369A, although his book was written to show that Herschel was quite wrong in his conclusions on this very matter.

To show how far even the most extreme midsummer and midwinter temperatures are from being proportional to the sun-heats received at those times, take Yakutsh in Siberia, supposed to be the most extreme of terrestrial climates. The excess of its summer temperature over the — 239° F. is about 309° F., and of its winter temperature about 199° F., but the midsummer sun-heat is to the midwinter sun-heat as 5800 is to 199, or as 309 is to 11. Hence we may draw two conclusions: if the excess of midwinter temperature over — 239° F. be due to the midwinter sun-heat, then, on Croll's theory, the midsummer temperature ought to be 5800° F. above the — 239° F.; or if, on the other hand, the summer excess of 309° F. be due to the summer sun-heat, then the midwinter temperature ought, if only dependent on sun-heat, to be only 11° F. over the — 239° F., *i.e.* it ought to be — 228° F., and the rest of the 199° F. excess over the — 239° F. must be due to heat derived from other regions of the earth. If we apply this reasoning to Great Britain the difference will be more striking still, because there the midwinter excess over the — 239° F. differs little from the midsummer excess. If, instead of taking Croll's sun-heat on the single days of least and most insolation, we take Ball's *average* daily summer and winter sun-heat, the result is not, perhaps, so grotesquely different from the assumption, but it is sufficiently different to show the absurdity of the supposition; for the ratio of the average daily sun-heat in summer to that in winter is about 1000 to 199, or 309 to 62. Hence, if the winter temperature be due to the sun-heat, the summer temperature should be 1000° F. over — 239°, or, say, 760° above the zero of the Fahrenheit scale; or, if the summer temperature be that due to sun-heat, then the winter temperature ought to be — 239°+62° F., or — 177° F., instead of about — 40° F.

The plan which I have adopted for measuring the fall in temperature is as follows:—It is not difficult to ascertain what parallel of latitude *now receives the same winter sun-heat as parallel* 50° *received in the period of great eccentricity when the winter was in aphelion.* We can also do this for the parallels of 40°, 60°, 70°, 80°, and 90°. I have made the necessary calculations on three different suppositions. First, following Croll's idea, I find what parallels

now receive the same *midwinter* sun-heat; second, following Ball's method, I find what latitudes now receive the same *daily average* of sun-heat in winter, *i.e.* from equinox to equinox; third, I find what latitudes now receive the same total amount of sun-heat in their coldest 199 days as the others (40°, 50°, etc.) receive in the 199 days of the supposed Glacial winter. The results are:—

First Comparison.

Latitudes 43°, 52°, 61°, 70°, 80°, and 90° now receive on midwinter day, the same or slightly less heat than latitudes 40°, 50°, 60°, 70°, 80°, and 90° received on the midwinter day in the epoch of great eccentricity. Hence, on Croll's hypothesis, we should expect the midwinter temperatures of 40°, 50°, etc., in that epoch to be about the same as those of 43°, 52°, etc., at present.

Second Comparison.

Latitudes 43·3°, 52·4°, 61·7°, 71·3°, 81°, and 90° now receive in their winter of 179 days the same or slightly less daily average of sun-heat as 40°, 50°, 60°, 70°, 80°, and 90° would receive in their supposed Glacial winter of 199 days.

Third Comparison.

Latitudes 42 2°, 54°, 63·5°, 74°, and 84·5° now receive about the same daily average of sun-heat in the 199 coldest days of the present year as 40°, 50°, 60°, 70°, and 80° received in the 199 coldest days of the period of great eccentricity.

A

It is evident that in order to find those latitudes whose *midwinter* temperatures are now the same, so far as direct sun-heat is concerned, as those of 40°, 50°, 60°, 70°, and 80° in the period of great eccentricity, we must take the latitudes somewhere about those given by the second method. For though the *midwinter* sun-heat received now by the latitudes thus obtained is decidedly less than that received by 40°, 50°, etc., in the earlier period, yet as the daily average remained at its small value during a slightly longer time in the winter of great eccentricity, there might on that account be a somewhat lower midwinter temperature (though as the lowest temperature occurs in January all over the earth, it is not likely that the extra time would produce much effect).

As to the latitudes given by the third method, they receive so much less sun-heat during the middle of the winter than 40°, 50°, etc., received in an equal time during the epoch of great eccentricity that it seems quite evident that the present *midwinter* temperatures of 44·2°, 54°, 63·5°, 74°, and 85° must be considerably lower than those of 40°, 50°, 60°, 70°, and 80° were in the period of great eccentricity, so that we are quite safe in taking them as giving the extreme limit of possible change of climate, due *directly* to the diminished sun-heat.

Now to find the fall in temperature. As we go northwards from lat. 50° to lat. 70° the decrease in midwinter temperature is 15° F.

in the meridian of Greenwich, and a mean of 25° F. in the central meridians of the American and Asian continents; in other words, the midwinter temperature of 54° N. is at present about 5° F. lower than that of 50° N. in the continents, or, in the meridian of Greenwich, about 3° F. lower. (This is, of course, taking the *average* rate of fall between 50° N. and 70° N.) But the present midwinter temperature of lat. 54°, *as directly dependent on sun-heat*, has been shown to be lower than that of lat. 50° was in the epoch of great eccentricity. Hence the temperature of lat. 50° in the supposed Glacial epoch cannot, so far as direct sun-heat is concerned, have been as much as from 3° F. to 5° F. lower than its present temperature. Similar reasoning applies to the other latitudes.

Thus the conclusion is that the lowering of midwinter temperature from 50° N. to 70° N. due to diminshed winter heat in the epoch of great eccentricity cannot have been as much as from 3° F. to 5° F.

Another way to look at it is, that the midwinter sun-heat temperature of England, which is included between the parallels of 50° and 55°, cannot have been as low as that of the region from York to the Orkneys is now.

Thus the foundation of the astronomical theory breaks down completely. It requires us to suppose that the same quantity of sun-heat as that which now, falling on Yorkshire, gives us a mild and equable climate, will, if it falls on Cornwall, produce an Ice Age; or again, that if the present winter sun-heat at Oxford were to be reduced to the amount which now falls at Melrose Abbey, such deluges of snow would cover Oxford that a summer heat *far greater than that now received there* would be unable to melt it, so that from year to year so great an accumulation of snow would result that the Gulf Stream would be turned back to the Southern Hemisphere. Observe, *a summer heat far greater than that now received at Oxford;* for, in the 166 days of the short hot summer of great eccentricity, Oxford would receive as much summer heat as is now received in an equal time by latitude 35°, say by Tangier or Algiers (see a paper in the Phil. Mag. of December, 1894).

But it is unlikely that there was any fall whatever in midwinter temperature in Great Britain during the epoch of great eccentricity; for, as we have seen, that temperature depends very greatly on the heat received from the Gulf Stream. Now, between the Azores and Ireland, the Gulf Stream is known to travel at the rate of about 3·9 miles per day, or 10 degrees in six months. Therefore, the waters whose warmth in winter keeps our climate so temperate, depend for a great portion of that winter warmth on the summer sun-heat received at a point 10 degrees to the south-west on their path; and this, as I have said, was far greater in the epoch of great eccentricity.

The numbers I have given all relate to the greatest possible eccentricity of the orbit. If we apply them to the considerable eccentricity of about 100,000 years ago, as calculated by Leverrier, we must reduce them by about one-fourth part.

(D) With the disappearance of (C), this argument also disappears.

No doubt, if there were a fall of anything like 45° F. in the mid-winter temperature of Great Britain, there would be a great increase in the fall of snow; as it is, I have shown that there would be none worth speaking of—nothing that would not be melted by a couple of soft winter days.

(E) We now come to a point on which Croll insists at great length, namely, that summer heat is less effectual in melting winter snow than winter cold is in producing it. I might pass this by as I have passed (D) by, on the ground that there would be no snow to melt, but the question is so important from a climatic point of view, and so much of the evidence seems strongly opposed to Croll's view, that it is worth examining the matter at some length, especially as Croll's view on this point is almost as necessary to the astronomical theory as the views already dealt with in (C).

According to Croll (pp. 58–60), there are three separate ways whereby accumulated masses of snow and ice tend to lower the summer temperature, viz.:—

First, by direct radiation. No matter what the intensity of the sun's rays may be, the temperature of snow and ice can never rise above 32°. Hence their presence tends by direct radiation to lower the temperature of all surrounding bodies to 32°. . . . .

[Here follow illustrations as to the summer cold in Greenland and the high Alpine regions; also the statement that if India were covered with an ice-sheet, its summers would be colder than those of England.]

Second. Another cause of the cooling effect is that the rays which fall on snow and ice are, to a great extent, reflected back into space. Even those which are not reflected but absorbed, do not raise the temperature, for they disappear in the mechanical work of melting the ice. . . . .

Third. Snow and ice lower the temperature by chilling the air and condensing the vapour into thick fogs . . . which would effectually prevent the sun's rays from reaching the earth, and the snow in consequence would remain unmelted during the entire summer.

Here follow several pages of illustrations of cold climates, those of Greenland and Hudson's Bay in the Northern Hemisphere, and South Georgia, Sandwich Land, South Shetland, Straits of Magellan, and other places in the drift-currents coming from the Antarctic regions. Thus Croll's examples are all open to the fatal objection that they are selected from regions where the sun-heat has to contend, not only with the ice or snow actually on the ground, but with cold drift-currents which bear great masses of ice and snow from the Polar regions.

A question of this kind cannot be settled by such an eclectic method. It is not by taking all the cases which at first sight may appear favourable to the view we desire to uphold that we shall arrive at the truth. No doubt there are regions exposed to cold currents of Arctic or Antarctic origin which are very much colder in summer than we should expect from the sun-heat corresponding to their latitudes, just as there are regions where, owing to warm

ocean currents, the winter temperature is much higher than we should anticipate if we neglected every consideration save the winter sun-heat received; but we must make our selection of instances in a fairer way than by taking any one of these groups.

No doubt direct sun-heat falling on ice or snow is not a very powerful factor in giving rise to a thaw. Even in these climates we may verify that observation. Often there are bright crisp days with a northerly wind after a fall of snow, and though we may enjoy the warmth of the sunshine, the snow lies on the ground apparently unaffected by it. But soon comes a southerly wind, on a raw misty day, which feels perhaps far colder to us, and a sudden thaw sets in. The snow, which has been hard, becomes soft and sloppy, and finally disappears with wonderful rapidity, as often during the night as during the day. From this we learn that though sun-heat falling directly on ice or snow may have but little effect in melting it, yet it is a most effective agent if first applied to warm the land or sea elsewhere, and thus indirectly to warm the air passing over it, which air afterwards passes over the snow.

What we see on a small scale here is displayed on a vast scale in the sudden thawing of the great river basins which empty into the North Polar Sea. Mr. Henry Seebohm, in his "Siberia in Asia," describes how suddenly the river ice breaks up, and with what almost inconceivable rapidity the snow thaws over a vast extent of country when the south wind sets in. In the companion book, "Siberia in Europe," p. 89, he says: "Summer now [10th May] seemed suddenly to have burst upon us in all its strength; the sun was scorching, the snow in many places melted so rapidly as to be almost impassable." But by far the most striking account is in his Presidential Address to the Geographical Section of the British Association in 1893. Here he speaks of the "great suddenness" with which the snow melts. Again (Report, p. 828): "The stealthy approach of winter on the confines of the Polar Basin, is in strong contrast to the catastrophe which accompanies the sudden onrush of summer."

Again, speaking of the coming of summer in the basin of the Yenesei: "During the month of May there were a few signs of the possibility of some mitigation of the rigours of winter. Now and then there was a little rain, but it was always followed by frost. If it thawed one day, it froze the next; and little or no impression was made on the snow. Between May 16 and 30 . . . . migratory flocks of wild geese passed over our winter quarters; but if they were flying north one day, they were flying south the next, proving beyond doubt that their flight was premature. The geese evidently agreed with us that it ought to be summer; but it was as clear to the geese as to us that it really was winter. We afterwards learnt that during the last ten days of May a tremendous battle had been raging 600 miles as the crow flies to the southward of our position on the Arctic circle. Summer, in league with the sun, had been fighting winter and the north wind all along the line, and had been hopelessly beaten everywhere, as we were witnesses that it had

been in our part of the river. At length, when the final victory of summer looked the most hopeless, a change was made in the command of the forces. Summer entered into an alliance with the south wind. The sun retired in dudgeon to his tent behind the clouds, mists obscured the landscape, a soft south wind played gently on the snow, which melted under its all-powerful influence like butter upon hot toast; the tide of battle was suddenly turned, the armies of winter soon vanished into their water and beat a hasty retreat towards the pole. The effect on the river was magical. Its thick armour of ice cracked with a loud noise, like the rattling of thunder; every twenty-four hours it was lifted up a fathom above its former level, broken up first into ice-floes and then into pack-ice, and marched down the stream at least a hundred miles [in the 24 hours]. Even at this great speed it was more than a fortnight before the last straggling ice-blocks passed our post of observation on the Arctic circle, but during that time the river had risen 70 feet above its winter level, although it was three miles wide; and we were in the middle of a blazing hot summer, picking flowers of a hundred different kinds, and feasting upon wild ducks' eggs of various species. Between May 29 and June 18, I identified sixty-four species I had not seen previous to the break-up of the ice."

And yet on June 1st the snow was 6 feet deep at his post of observation, and averaged 5 feet in the million and more square miles which are drained by the Yenesei, an area four times that drained by the Danube: *so suddenly did the south wind melt an area of one million square miles covered with snow 5 feet deep.* Nor is this out of keeping with what occurs in the other Arctic river basins. As Mr. Seebohm puts it (p. 828), "the sudden arrival of summer on the Arctic circle appears to occur at nearly the same date in all the great river basins," though probably nowhere else is it so striking as in the Yenesei.

What becomes of Dr. Croll's theory of the difficulty of melting the snow? Surely we might, with more plausibility than Croll, affirm that the Glacial period was that of the short winter and long summer. For the greater heat in winter would then be almost wholly given to the more southern or tropical regions of the hemisphere, no difference whatever being made in the heat received at the North Pole; and since the summer heating of the Gulf Stream would be much smaller than at present, it would convey less heat northward in winter than at present. Hence we might then have even more winter snow in northern latitudes than now, while in the cooler summer we might look in vain for the same generous warmth in the south wind, and so the snow would increase over the more northern Arctic regions, and by cooling these would spread further and further south, till at last the whole land was wrapped in its icy mantle; and so on. In truth, when once we leave the region of quantitative results, and plunge into that of loose argument, we are reminded of the proverb—you pay your money and you take your choice. The subject is so complicated that a skilful advocate can always make out a plausible case by carefully selecting the

arguments which support the view he defends, and leaving out all the others.

Still, I think that, after reading Seebohm's graphic account of the extraordinarily sudden triumph of summer, no one will be disposed to adopt Croll's view as set forth in (E).

(F) It seems hardly necessary to discuss this argument now. It is easy to see, and is shown in the paper already referred to, that there is even less difference, so far as sun-heat is concerned, between our present climate and that of the supposed "genial age" than between our climate and that of the supposed "Glacial age."

(G) Whether the stoppage of the Gulf Stream would result from a great lowering of temperature over the northern hemisphere is a point I am not prepared to give an opinion upon. But as an argument in connection with the astronomical theory, it is absolutely dependent on the previous acceptance of (C), (D), (E), and (F), and as these have been shown to be quite erroneous, it is unnecessary to examine into (G).

(H) In taking this position as to the summer fall of snow, Croll shows such a courageous resolve to take the bull by the horns, that a close criticism seems too prosaic, and the best course is to allow (H) to march out with all the honours of war.

(*To be continued.*)

III.—On a Soda Felspar Rock at Dinas Head, North Coast of Cornwall.[1]

By Howard Fox, F.G.S.

DINAS HEAD is a promontory 4 miles west of Padstow, jutting out into the sea from Trevose Head, and separated from it by an isthmus about 100 feet above sea-level, which is washed clear of soil by the ground seas which sweep over it from the north. The headland is 165 feet above sea-level at its highest point, and is almost as broad from north to south as it is long from east to west. The base and foreshore of the headland appear to be entirely composed of greenstone containing much calcite. The microscope shows it to be probably an altered dolerite.

Between the greenstone and the slate of the district, as well as interbedded with the slate, we find a rock that covers about an acre, and assumes various characters, but all of which contain nearly 10 per cent. of soda and from 64·4 to 66·6 per cent. of silica. The compact varieties of this rock are crypto-crystalline, and may easily be mistaken for cherts. The concretionary and spherulitic varieties show grains and blades of a felspar, which is doubtless albite. It varies in colour from creamy-gray to light-brown and dark bluish-gray; it weathers white, and is often studded with cavities, some of which are not unlike pholas-holes. These cavities are filled with a rusty-brown material containing crystallized quartz. In other places this rock contains lenticles and concretions of calcareous matter of considerable size, and, when it is interbedded with slate, it is densely studded with small rusty-brown spots, sometimes

[1] Read at the British Association Meeting, Oxford, August 10th, 1894.

irregular, and sometimes of such forms as would be yielded by rhombs; they are undoubtedly pseudomorphs after a ferriferous carbonate. It has, in places, all the appearance of a stratified rock, and is distinctly banded.

In one locality it assumes a nodular form with the nodules at the outer edges of the rock, showing a radiated or spherulitic structure. The spherulites vary from 2 to 10 mm. in diameter.

The greenstone is posterior to and intrusive in this rock, and abruptly cuts across, bends, and disorders its beds. Extreme crushing has, in places, altered the original junction-line between the two rocks, and thrust-planes and fault breccias are seen. Quartz-veins traverse both rocks, but are more numerous in the soda rock.

The slate is occasionally full of ferruginous spots, and contains rusty-brown concretions in the same manner as the soda rock; it is, on the northern side of the headland, interbedded with bands of blue limestone from a few inches to several feet in thickness. There are a few bands of dark impure chert at the western end of the headland.

A rock, rich in soda, called Adinole is said to occur as a contact product due to greenstone in the Hartz.[1] The question arises whether this Dinas Head rock is an Adinole or a soda felsite. Before stating the difficulties in the way of either hypothesis, we will examine the headland more in detail.

In approaching Dinas Head from Trevose Head there are blocks of quartz lying about on the grass which from a distance look like sheep. These blocks are apparently fissure quartz. One of them which lies nearest to the public road to the lighthouse is composed of orbicular quartz, internally radiated, the individual radiated spheres varying in size up to 1 inch in diameter.

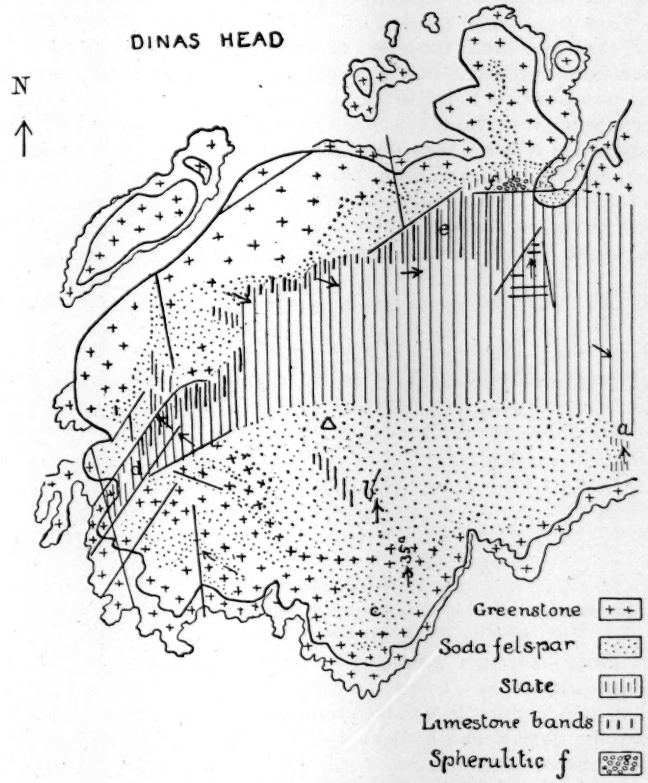
The isthmus connecting Trevose Head with Dinas Head is bare of soil, the slate exposed is thinly laminated, bluish-brown, and friable, with traces of badly-preserved organic remains. The slates show reeding structure. The sea-water that breaks over it from the north has worn channels to the edge of the precipitous cliff on the south side at "*a*" in the annexed Map (which is copied from the 25-inch parish map, and may be taken to be approximately accurate, though only indicating some of the numerous faults). In one of these channels, alternate beds of this soda rock and of slate are exposed for a length of thirty feet, dipping in a northerly direction in conformity with the prevailing dip of the district. The beds of the soda rock vary from 1 inch to several feet in thickness, they weather bluish-white, with prominent thin parallel bands or ridges so closely set that there is often only 1 mm. between them. The surface is pitted all over with minute cavities and brown spots. Mr. Teall kindly examined a section of this rock, and sent me the following description:—

"Compact banded bluish-gray rock with brown rusty spots. Under the microscope the structure of the main mass of the rock is seen to be crypto-crystalline, but the nature of the material cannot

[1] *Vide* Brit. Petrology, Teall, pp. 217–219.

be determined. The brown rusty spots are sometimes irregular and sometimes of such forms as would be yielded by rhombs. There can be no doubt that they are pseudomorphs after a ferriferous carbonate."

Proceeding westward we find near the highest point of the headland some slate surrounded by the soda rock at "*b*." The soda rock is here mostly compact, dark bluish-gray in colour, and weathers white. A knife will not scratch the dark rock but will scratch



Diagrammatic map of Dinas Head, 208 feet to the inch.

the white crust. One specimen from this spot shows the ferruginous material in closely set parallel bands, or in curved sutures, or massed together somewhat in circular form on one side, whilst the other side of the specimen is uniform in colour with several minute holes from $\frac{1}{2}$ to 1 mm. in diameter.

Descending the cliff due south from this point we pass over alternate exposures of greenstone and soda rock. The latter near the bottom of the descent is at "*c*" thinly bedded, dipping in a northerly direction at an angle of about 35°. It is studded with

cylindrical cavities, which have been filled with rusty-coloured material containing crystallized quartz. This rusty material occasionally weathers out as nodules 8–10 mm. in diameter, projecting from 10–15 mm. beyond the white surface of the rock. The rusty material has, however, in most cases worn away faster than the matrix, and left the rock dotted thickly with conspicuous rusty-coloured depressions. In some places the rusty material forms lenticles and fills up cavities between the beds of the rock.

Dr. Hinde examined a section of this rock for me, and thus refers to the white weathered portion: "The white crust appears as if of a flaky character and forming numerous extremely thin layers. Whether these represent layers of original bedding seems doubtful, but it is possible that it might be so."

As we proceed in a north-westerly direction from "*c*" we pass over exposures which show that the igneous rock was posterior to and intrusive in the soda rock, the beds of the latter being bent, disordered, and cut across, as seen in Fig. 2, which with Figs. 1 and 3, are taken from the original sketches of Sir Archibald Geikie, whom I had the pleasure of accompanying to the spot.

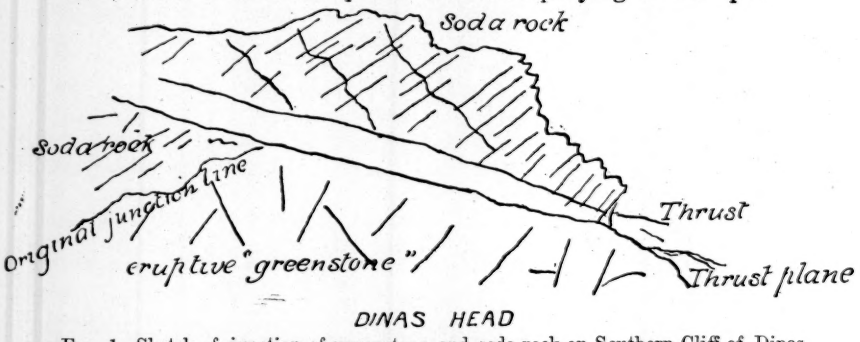


Fig. 1. Sketch of junction of greenstone and soda rock on Southern Cliff of Dinas Head, showing movement since intrusion of greenstone.

That there has been considerable movement since the intrusion of the greenstone is shown by Fig. 1, where a thrust-plane is indicated. In some places the rocks have been shattered and re-cemented by quartz, and quartz-veins run through both the igneous and the soda rock, being more numerous in the latter. In one place a mass of soda rock 15 feet long is enclosed in the greenstone.

Further west we find the cliff shattered with faults, and at "*d*" the soda rock and the dark compact slates contain round and oblong rusty-coloured concretions of dolomitic character, from an inch to several feet in diameter. The concretions frequently have concentric structures around them. Just above "*d*" there are dolomitic bands 4 feet thick, as shown in Fig. 3. Here a dolomitic band "*b*," 4 feet thick, is interbedded with dark cherty slates "*a*," in which are concretions and lenticles of dolomite, many of the concretions having concentric structure. The thrust-plane "*c*" has a dolomitic fault breccia lying in cakes about it. A section of a concretion is

thus described by Mr. Teall: "A coarsely crystalline aggregate, mainly composed of a carbonate which does not effervesce with cold acid. Probably a dolomite."

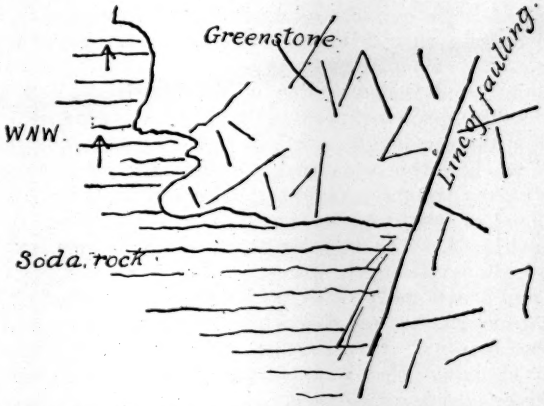
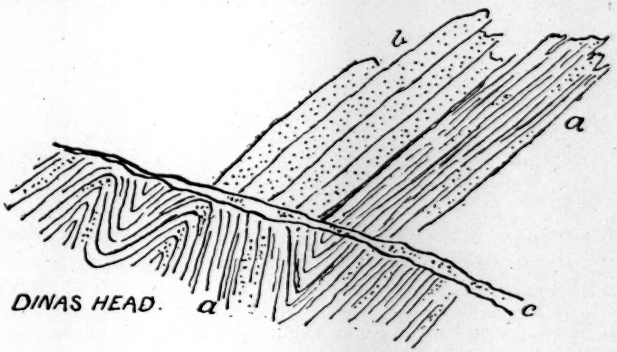


FIG. 2. Sketch of junction of greenstone and soda rock on Southern Cliff of Dinas Head, showing that the greenstone cuts across and disturbs the beds of the soda rock.

Further up the cliff the soda rock and slate are interbedded, both showing rusty-coloured lamination. The strata between these faults are much twisted and disordered. In one place a dark cherty band



IG. 3. Sketch of section on Western Cliff of Dinas Head, showing—
"*a*" Dark cherty slate with concretions and lenticles of dolomite. The concretions with occasional concentric structure.
"*b*" Dolomitic band about 4 feet thick interbedded with slate.
"*c*" Thrust-plane with a dolomitic fault breccia lying in cakes about it.

is seen to make a loop several feet long, enclosing calcareous rock.[1] Blue limestone bands are also interbedded with the slates in this district.

[1] We find similar bands of dark chert, rolled with dark calcareous rock, at Cataclews Point, 1½ miles east of Dinas Head.

Continuing our progress along the northern side of the headland, we find the greenstone and soda rock much intermixed, and compact blue slate is interbanded with numerous blue limestone bands, from a few inches to several feet in thickness, dipping south of east. Both slate and limestone occasionally weather in circular holes and contain rusty-coloured material in the same way as the soda rock.

Dr. Hinde found that a section of the blue limestone from "*e*" was principally made of echinodermal fragments, probably of crinoids, and there were also portions of Polyzoa like *Fenestella*.

At "*f*" we find this soda rock, for an area of 30 square feet, assuming a gray nodular character. The compact rock passes into one composed of gray nodules from 3 to 10 mm. in diameter, as shown in Fig. 4. The nodules at the outer edge of one portion of this rock show spherulitic structure. The spherulites are crowded together, and occasionally attain a diameter of 10 mm. Thin veins of quartz traverse the nodules, which often weather gray, in cup-shaped prominences. In other cases they weather white, and the polygonal sutures, filled with ferruginous matter, give the rock a scale-like or mosaic appearance.

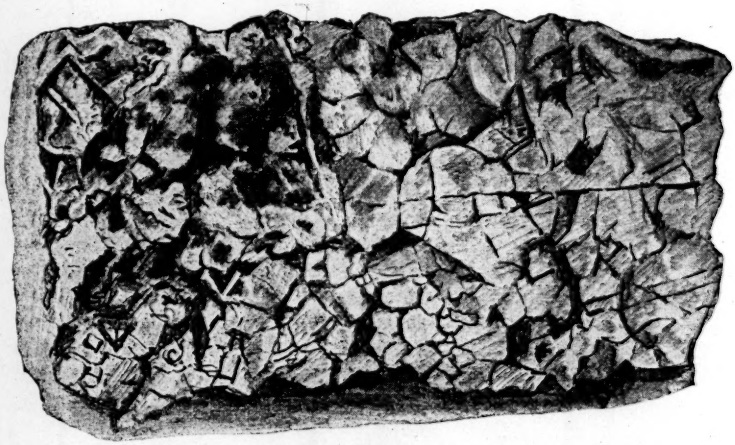


Fig. 4. Sketch (natural size) of gray nodular soda rock with spherulitic structure, from the Northern Cliff of Dinas Head.

Mr. Teall examined three sections of this rock, and reported as follows:—

"No. 353. A remarkable spherulitic rock. Spherules sometimes measuring $\frac{1}{4}$ inch in diameter.

The central portions of the spherules are generally composed of crypto-crystalline material. The outer portions of radiating blades or prisms of felspar, presumably albite. Ferric oxide, probably resulting from the decomposition of a ferriferous carbonate, is scattered through the slide in irregular patches, and concentrated in

veins. Some of the patches by their form suggest that the ferric oxide is a pseudomorph after a carbonate.

The interference of adjacent spherulites produce polygonal sutures, in which the ferric oxide is sometimes concentrated; but it occurs also in the spherulites.

No. 354. Similar to the last. Ferric oxide in radial streaks between the blades or prisms of felspar which form the radial portions of the spherulites.

No. 355. Similar to above, but with the ferric oxide almost wholly concentrated in the polygonal sutures formed by the mutual interference of adjacent spherulites."

As the microscope failed to disclose the composition of this rock, I sent specimens of the three chief varieties to Mr. J. J. Beringer, F.C.S., of Camborne, who kindly consented to analyse them. He entrusted much of the work to his pupil, Mr. Arthur F. Hosking, and sent me the following results :—

I. Specimen was the light brownish chert-like variety, weathering white, with cavities filled with rusty-brown material from "*c*" in map.

II. Specimen was the dark bluish-gray compact variety, weathering white, from "*b*" in map.

III. Specimen was the gray nodular variety from "*f*" in map.

	I.	II.	III.
Loss on ignition	1·7	1·3	1·6
Silica	64·4	64·8	64·6
Titanic acid	1·0	1·5	1·2
Alumina	20·2	19·9	20·4
Ferric oxide	0·7	0·7	0·7
Lime	1·6	0·7	1·3
Magnesia	0·2	0·1	0·1
Alkalies	10·4	10·2	10·1

Mr. Beringer adds: "The silica in III. was not directly determined. The alkali is mainly soda; by trituration with acid it represented 9·6 per cent. of soda, on the assumption that soda was the only alkali present. In I. and III. the bulk of the iron and lime is in a form easily soluble in acids; this is partly true of II., but the soluble fraction is very small."

In a subsequent communication Mr. Beringer informed me that the potash in one of these specimens was 0·47 per cent.

I am indebted to Mr. J. Hort Player, F.C.S., of London, for the following analysis of the compact light-brown chert-like rock from "*c*," free from weathered crust or nodules.

DINAS HEAD ROCK.

Silica	66·6
Titanic acid	·8
Alumina	19·6
Ferric oxide	·9
Ferrous oxide	·2
Magnesia	·3
Lime	·4
Soda	9·8
Potash	·7
Loss by ignition	·8
	100·1

April 28, 1894. J. HORT PLAYER.

These analyses show that if this Dinas Head rock be an adinole it contains a larger per-centage of soda than any adinole hitherto analysed.

Schenck found in the Hartz adinole 7·14 per cent. of soda in one specimen, and Kayser[1] found 7·54 per cent. of soda in adinole next the diabase.

That the greenstones of the Dinas Head district contain enough soda to account for the impregnation of sedimentary rocks into which they have intruded may be inferred from Mr. J. A. Phillips' analyses of many so-called greenstones in North and Central Cornwall, published in the Quart. Journ. Geol. Soc. for 1878, in which he records several of them as containing over 5 per cent. of soda; one as much as 5·84 per cent.

Supposing the Dinas Head rock to be an adinole, two difficulties have to be met: How does it become interstratified with slate? How do the spherulitic and concretionary structures arise?

Mr. Teall informs me that the presence of ferriferous carbonate favours the theory of its being an altered sedimentary rock, whilst the spherulitic and concretionary structures favour the theory of its being an igneous rock, viz. a soda felsite or keratophyre.

I am not prepared to explain the origin of this rock, but it is certainly of interest on account of its remarkable composition.

IV.—On some Fossil Ostracoda from Canada.

By Prof. T. Rupert Jones, F.R.S., F.G.S., etc.

(PLATE II.)

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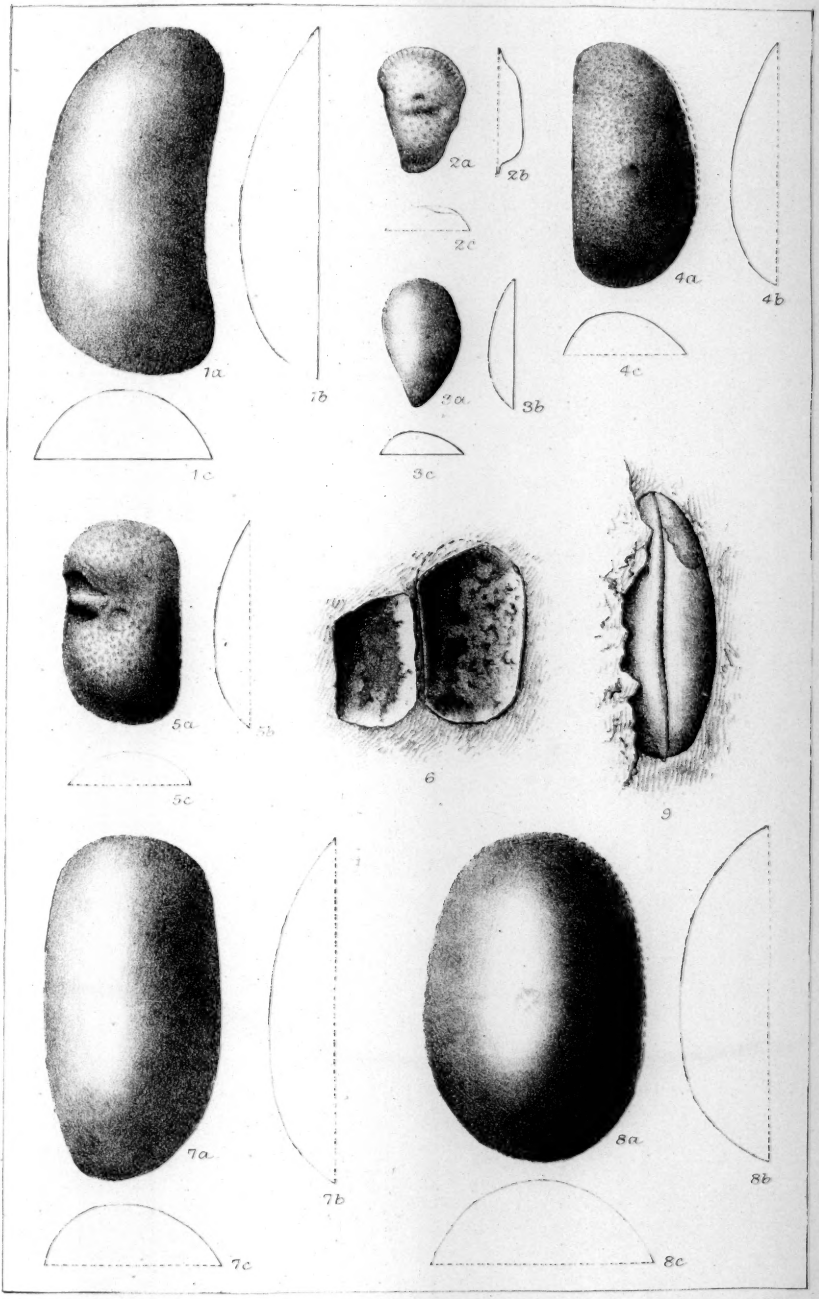
§ 1. *Introduction.*

THE specimens here referred to belong to the Geological Survey of Canada, having been collected—I. some (of Quaternary age) by Mr. J. B. Tyrrell, B.Sc., F.G.S., in 1887, on the Rolling River two miles above Heart Hill in Manitoba.

II. Small pieces of a loose block, lying by the South Branch of

[1] Kayser, Hartz Z. Geol. Ges. xxii. 1870, p. 103.



F.C. Knight del et lith. West Newman imp.

Fossil Ostracoda, Canada.

the Milk River, in Southern Alberta, North-west Territory, but belonging to the Saint-Mary-River Beds. Collected by Dr. G. M. Dawson in 1874, when he was the Geologist and Botanist to the British North-American Boundary Commission.

III. Some specimens from the Saint-Mary-River Beds of the Lower Laramie series, on the North Branch of the Milk River, and of either newest Cretaceous, or oldest Tertiary age; also collected by Dr. G. M. Dawson in 1874.

IV. One small specimen from the St.-Mary-River Beds; collected by Dr. G. M. Dawson in 1881, on the Old-Man River in the Alberta District.

With regard to II. and III. we note that in Dr. Dawson's "Report on the Geology and Resources of the Region in the Vicinity of the Forty-ninth Parallel," etc., 1875, the geology of the First [now the South] Branch of the Milk River is briefly noticed at page 130; and the Second [now the North] Branch (14 miles to the west) at page 131. The fossils generally at these sections appear to have freshwater characters for the most part (pages 155–158). See also further on, page 25.

§ 2. *Description of the Species.*

From among the several more or less distinct examples, the following have been selected.

Only with two or three of the figured specimens (as Figs. 1 and 3) is there direct evidence of the exact outline of the margins of the valves, as shown in Figs. *b* and *c* throughout the series, owing to the imbedment, or the close adherence of the valves to the rock by their edges. For the same reason, for want of direct evidence of the hingement of the valves, the generic position of the majority is very uncertain, and only provisionally suggested.

Mr. Frederick Chapman has kindly helped me in preparing and determining the specimens.

I. Seven small pieces of grey and yellowish friable marl, containing numerous thin shining valves, and casts of similar forms. These are from the Rolling River, Manitoba. The geological conditions are described at pages 115 E, and 116 E, of the "Report on North-western Manitoba, with portions of the adjacent districts of Assiniboia and Saskatchewan." By J. B. Tyrrell, M.A., B.Sc., F.G.S. Part E of Annual Report of the Geological Survey of Canada, vol. v. 1889–90–91. 8vo. Ottawa, 1892.

Thus:—

Rolling River was examined from a point a short distance west of the 101st meridian, where it is about 2250 feet above the sea. It is here a small stream in a valley fifteen feet deep, with a Spruce swamp on both sides. Its bed is covered with boulders, and its channel is much obstructed by beaver-dams. A short distance lower down it flows in a deep valley, the sides of which show some excellent sections of Pleistocene deposits. One of these sections on the north bank is as follows:—

	Feet.	in.
1. Stratified gravel	10?	0
2. Unstratified Till with striated pebbles	22	0
3. Stratified sandy clay, becoming almost a pure laminated clay at bottom, where it contains many plants and freshwater shells,—such as *Taxus baccata, Elodea Canadensis, Vallisneria*?, *Navicula lata, Encyonema prostratum, Denticula lauta, Licmophora, Cocconeis*; *Lymnæa cata-scopium*?, *Valvata tricarinata* (and a keelless variety), *Amnicola porata*?, *Planorbis parvus*?, *P. bicarinatus, Pisidium abditum*, and *Sphærium striatinum*	6	0
4. Stratified grey sandy clay	20	0
5. Slightly sandy stratified clay, coloured dark-brown with bituminous matter, and containing a few small bivalves	1	10
6. Plastic clay	5	0
7. Coarse stratified sand	12	0
Covered down to the water	12	0

The specimens under notice were probably taken from the stratum No. 3 of the foregoing section.

Candona, Baird, 1845.

1. Candona candida (Müller, 1785). Pl. II. Figs. 1*a*, *b*, *c*.

Length 1·88, height ·88, thickness ·8 mm.

The most common Ostracods in these marls are such as is shown by Fig. 1, evidently closely related to, and probably identical with, the freshwater *Candona candida* (Müller), especially as shown by pl. i. figs. 8*a*, *b*, *c*, and described at p. 19, "Monogr. Tert. Entom. England," Palæont. Soc. 1856, and "Supplement," 1889, p. 13. The posterior extremity, however, is thicker than in fig. 8*b*, and is such as is seen in some varieties of the species, as depicted by Brady and Norman in pl. 10, "Transact. Royal Dublin Society," series 2, vol. iv. p. 38, 1889, and chiefly in the male individuals. For a bibliography of *Candona candida* as a living Ostracod, see Wenzel Vávra's memoir on the Ostracoda of Bohemia, in the Archiv naturw. Landesd. Böhmen, vol. viii. No. 3, 1891, p. 48.

The specimens under notice are subreniform and rather elongate; with unequal ends, the anterior being smaller and more compressed than the posterior extremity. The dorsal margin is arched, but straight along the hinge-line; the ventral edge is sinuous, with its middle part incurved. Surface smooth, neatly and moderately convex; somewhat fuller behind than in the front third.

Several in the freshwater marl on the Rolling River, which at about 101° W. Long. and 64° N. Lat. runs from the Ducks Mountains into the Swan River for the Swan Lake; and this is connected with the south side of the northern part (Dowson's Bay) of the Winnepegosis Lake, in Manitoba. See the Geol. Mag. 1893, p. 388, for some remarks on an analogous *Candona* from the Montana formation in Utah, U.S.A.

One or more specimens having the appearance of *Ilyobates reptans* are imperfect.

CYTHERIDEA, Bosquet, 1850.

2. CYTHERIDEA TYRRELLII, sp. nov. Pl. II. Figs. 2*a*, *b*, *c*.

Length ·72, height ·44, thickness ·32 mm.

Trigonal, broadly rounded in front, obliquely subacute behind; surface not much raised, almost flat, and sloping off suddenly to the edges. Two or three small knobs or pimples are grouped on the middle of the valve, and near by there is one larger and closer to the dorsal edge. The surface also is punctate.

The outline and sculpturing of the shell are not strange in *Cytheridea*; *C. Muelleri*, var. *torosa*, Jones (Monogr. Tert. Entom. p. 42, pl. vi. fig. 12, is one of the nearest of the published forms). The species under notice, named after its discoverer, is rather common in the marl from Rolling River, Manitoba. It probably lived in brackish water.

The species Nos. 1 and 2 indicate freshwater and brackish condition for the deposits in which they occur.

II. Seven small pieces of an "unattached" block, found on the South Branch of the Milk River. They consist of dark-brown or blackish limestone, containing small Gasteropods like *Paludina* and fragments of *Cyrena*-like valves, together with several black and dark-brown, shining Ostracoda. Although met with where the South Branch runs over the Belly-River Beds[1] (Cretaceous),[2] this block was recognized as belonging to the Saint-Mary-River Series, as explained at 37 C of the "Geological and Natural-History Survey and Museum of Canada, Report of Progress, 1882–3–4," 8vo. Montreal, 1885, with maps.

PONTOCYPRIS, G. O. Sars, 1865.

3. PONTOCYPRIS PYRIFORMIS, sp. nov. Pl. II. Figs. 3*a*, *b*, *c*.

Length ·72, height ·4, thickness ·32 mm.

Trigonal, pear-shaped, boldly-rounded in front, contracted to a sharp point behind; boldly arched on the dorsal and sloping with a slight sinuosity on the ventral border, both meeting at an acute angle posteriorly. Surface smooth, moderately and almost uniformly convex, but slightly more swollen towards the ventral region. Probably of brackish-water habitat. One valve in blackish limestone from an unattached block found at the South Branch of the Milk River, N.W. Territory.

Among several published forms more or less resembling this in shape, one variety of Reuss's *Cytherideis lævigata* (in Geinitz's "Elbthalgebirge in Sachsen," 1874, p. 150, pl. xxviii. fig. 3) is perhaps the nearest in shape, but it is not so pyriform, and is much

[1] These strata on the South Branch (Report of Progress, 1885, page 39 C) show sandstones, with some ironstone; and a few miles further down these are overlain by greyish and blackish bedded shales and sandstones, with a carbonaceous layer; and in them, among some fragments of shells, *Unio* was determined.

[2] *Ibid.* p. 119 C.

thicker, the valve being more convex. A much more pyriform valve of *Pontocypris*, with an acute posterior extremity, is Reuss's *Bairdia subfalcata*, Sitzungsb. Akad. Wiss. Wien, vol. xviii. 1885, p. 253, pl. ix. fig. 91; but it is much narrower than our Fig. 3, and its ventral margin is much more incurved.

One specimen in the loose block of Saint-Mary-River Beds.

Cypris, Müller, 1785.

4. Cypris Dawsoni, sp. nov. Pl. II. Figs. 4*a*, *b*, *c*.

Length 1·32, height ·64, thickness ·56 mm.

A neat suboblong valve, straight on the ventral, elliptically curved on the dorsal margin; ends almost equal in their semicircular curve, but the anterior rather smaller and more compressed than the posterior; both curving off from the dorsal and meeting the ventral margin with a definite angle. Surface gently convex; smooth; minutely dimpled with probably the remains of a punctation nearly worn away or partially dissolved; it is also marked centrally with an obscure dark muscle-spot.

Named after Dr. G. M. Dawson, F.R.S., who collected this and many other interesting specimens of Natural-history in his expedition along the 49th parallel.

There are some few forms of the marine genera *Xestoleberis* and *Krithe* that have an approach to this figure in shape; but it is among some freshwater genera that we find the nearest resemblances. Ostracods of this form, with straight ventral and well-arched dorsal margin, and nearly equal ends, are mostly found among the freshwater *Cyprididæ*; and of the published figures we may point to—

1. *Cypris incongruens*, Ramdohr. Trans. Linn. Soc. vol. xxvi. 1868, p. 363, pl. xxiii. figs. 16-19.
2. *Scottia Browniana* (Jones). Trans. R. Dublin Soc. ser. 2, vol. iv. 1889, p. 72, pl. ix. figs. 23, 24.
3. *Erpetocypris strigata* (Müller). *Ibid.* p. 85, pl. viii. figs. 14, 15.

The first, however, differs from our Fig. 4 in the outline of both extremities; the second is by far too tumid, and has a too boldly arched back; and the third has the proportions of the ends reversed, that is, it is somewhat higher in front than behind.

This one specimen is in a piece of the loose block found at the South Branch of the Milk River, but belonging to the Saint-Mary-River Beds higher up the valley.

Ilyocypris, Brady and Norman, 1889.

5. Ilyocypris oblonga, sp. nov. Pl. II. Figs. 5*a*, *b*, *c*.

Length 1·12, height ·6, thickness ·10 mm.

Oblong, slightly sinuous on the dorsal and quite straight on the ventral margin, gently curved at the ends, each of which meets the dorsal edge with a curve, and the ventral with a blunt angle. The anterior slightly smaller than the other end. Surface gently and irregularly convex, sloping down to the edges; obscurely dimpled all over; marked with an obscure central muscle-spot in a faint

depression, and behind it with two roughly triangular sulci, close together, and reaching to the hinge-line.

Candona euplectella, Robertson, Brady, and Norman, has a nearly oblong outline, but no sulcus, and is too thick to be comparable with our Fig. 5. On the other hand, some examples of the freshwater *Limnicythere* and *Ilyocypris* have variable transverse depressions and suboblong valves; and of these *Ilyocypris gibba*[1] (*Cypris*, Ramdohr) has the nearest resemblance to Fig. 5. *Bythocythere constricta*, G. O. Sars, is one of the few analogues among the marine *Cytheridæ*.

Four specimens in fragments of the unattached block of Saint-Mary-River Beds, above mentioned.

Nos. 3, 4, and 5 indicate brackish and freshwater habitats.

III. Six small specimens of light- and dark-brown limestone, four from the nodular, and two from the concretionary layer. with small *Paludinæ*, from the North Branch of the Milk River, which, in the "Report of Progress, Geol. Survey of Canada," 1885, at pages 13 C and 36 C, is described as rising in the foot-hills south of the 49th parallel; crossing that line near the 113th meridian, it pursues a north-easterly tortuous course. Its North Branch was termed the "Second Branch" in the "Report on the Geology and Resources of the 49th Parallel," p. 131; and its geology was described in the "Report of Progress," 1885, pages 36 C and 37 C, thus:—

The strata in the river-valley here belong to the Saint-Mary-River subdivision, showing about fifty feet of soft sandstones and shales, with harder bands, one of which is a nodular ferruginous limestone, one foot thick, with *Bulinus*, *Limnæa*, *Physa*, and *Sphærium*. A *loose* block of similar rock was found about fourteen miles south-eastward, at the crossing of the 49th parallel and the South Branch of the Milk River (termed "First Branch" in the Report of 1875); and the stratum to which it belonged is the same as that occurring in the upper part of the Saint-Mary-River Series (page 58 C). This series constitutes the lowest portion of the Laramie formation; and consists of sandstones, shales, and shaly clays in frequent alternations, and generally well bedded. Freshwater except near base: 2800 feet. See also pages 114 C, 97 C, 57 C, and 37 C, for other details. With the Willow-Creek Beds, next in upward succession, and the Porcupine-Hill Beds at the top, these three subdivisions constitute the Laramie Group in the District of the North-west Territory. But some of the Laramie is regarded as transitional from the Cretaceous to the Tertiary; the plant-remains being Tertiary, and the other fossils Cretaceous.

CYTHERE, Müller, 1785.

6. CYTHERE, sp. indeterminate. Pl. II. Figs. 6*a*, *b*, *c*.

Length 1·0 ? height ·6 mm.

Two contiguous valves, showing insides; both imperfect, but one

[1] For Synonyms, see Supplem. Monogr. Tert. Entom. Pal. Soc. 1889, p. 9; and Trans. R. Dublin Soc. ser. 4, vol. ii. 1889, p. 107.

of them (apparently a right valve) retains all its outline except the antero-ventral curve. The edges have been divested of their special characters by the loss of substance.

Valve broad-oblong, with the dorsal and ventral margins nearly straight and parallel; hinge-line distinct but not the method of hingement; semicircular posteriorly, and obliquely rounded (broken) anteriorly.

Such subquadrate carapaces occur among species of *Cythere*, *Cytheridea*, and *Loxoconcha*: as *Cythere fusca*, *C. Jurinei*, *C. lutea*, and *Loxoconche pusilla*. In the "Proceed. Bath Nat. Hist. Antiq. Field Club," vol. vi. 1868, pl. i. fig. 6, shows such an oblong *Cythere*, and figs. 5, 7, and 8 some *Cytherideæ* of similar shape, all from the Fuller's-earth Oolite.

The absence of characteristic features beside the mere outline precludes a definite determination beyond the fact that the species may be assigned to the marine genus *Cythere*.

This specimen of two valves occurs on the same piece of limestone with Fig. 7.

Candona, Baird, 1845.

7. Candona (?) Sanctæ-Mariæ, sp. nov. Pl. II. Figs. 7*a*, *b*, *c*.

Length 1·84, height ·92, thickness ·8 mm.

Suboblong and irregularly elliptical; semicircular in front, narrower and obliquely rounded behind; ventral edge slightly convex, dorsal partly straight (on the hinge-line), rapidly curving in front, and curved with a gentler slope behind, making a narrow and almost subacute oblique posterior margin. Surface smooth and uniformly convex, but more gently sloping in the dorsal than in the ventral region (Fig. 7*c*).

Two specimens in greyish-brown limestone of the nodular layer, with small molluscs like *Paludina*, *Planorbis*, etc. From the North Branch of the Milk River.

This form of carapace-valve is rare among the Ostracoda generally, but there is an approach to it in *Cythere* sometimes (as in *C. teres*, Trans. R. Dublin Soc., n.s. vol. iv. p. 133, pl. xiv. figs. 36, 37); also occasionally in *Krithe*, but from this it differs posteriorly. Its nearest figured representative is the freshwater *Candona lactea* as shown in the Trans. Linn. Soc. vol. xxv. pl. xxiv. figs. 54–58.

Cytherella, Bosquet, 1852.

8. Cytherella crucifera, sp. nov. Pl. II. Figs. 8*a*, *b*, *c*.

Length 1·75, height 1·2, thickness 1·04 mm.

Valve obtusely suboval; ends almost equal; one edge less fully curved than the other; uniformly convex, smooth, and marked with a small, round, central depression, which is divided into four little triangular spaces by a very slightly raised, whitish, cruciform line.

Unfortunately we cannot judge of the marginal characters of this specimen. The oval and smooth aspect suggests the marine *Cytherella* for the genus; and the full convexity is not inimical to

the idea, for *C. ovata* (Roemer), *C. elliptica*, Brady, and particularly *C. lata*, Brady, are more convex than the generality of the species; and so also *Bosquetia robusta*, Brady, Robertson, and Norman, a near ally, though smaller, is relatively quite as convex. None of these exhibit so peculiar a muscle-spot as is seen in Fig. 8*a*. The valve under notice probably belonged to a *Cytherella*, but is different from any known.

One specimen from the Saint-Mary-River Beds on the North Branch of the Milk River, North-west Territory.

The species Nos. 6 and 8 indicate marine, and No. 7 freshwater conditions, for the Saint-Mary-River Beds from which they came. Sometimes fluviatile species are brought down to the sea-beaches; and for an example see Monogr. Tert. Entom. Pal. Soc. 1856, page 17. Nos. 3, 4, and 5 (pages 23, 24) from a loose block of Saint-Mary-River Beds are freshwater and brackish, without anything definitely marine. No. 9 also, from the Old-Man River, is in favour of freshwater conditions.

IV. One small specimen of brownish limestone of the Saint-Mary-River Beds from the Old-Man River, Alberta District, North-west Territory. It contains a distinct joint-edge, in the united dorsal margins of two valves of an Ostracod.

The Old-Man River, a tributary of the Belly River, runs eastward (about 48° 40′ N. lat.) from the Livingstone Range (about 114° 40′ W. long.); and its "north bend" (about 49° 70′ N. lat. and 113° 50′ W. long.) runs on the Saint-Mary-River subdivision (lowest) of the Laramie formation. See the "Report of Progress" for 1882–84, page 67 C, and Map No. 1.

Candona, Baird, 1845.

9. Candona (?), sp. indeterminate. Pl. II. Fig. 9.

Length 1·44, height ?, thickness ·56 ? mm.

Dorsal junction of two valves; hinge-line defined by the slight prominences terminating the inflection of the edges.

This resembles to some extent the external appearance of the hingement and dorsal aspect of several species among the marine *Cytheridæ*,—namely, *Cytherura*, *Xestoleberis*, *Krithe*,—but more closely that frequently seen in the freshwater *Cypris* and *Candona*, such as *Cypris virens*, *Candona elongata*, and *C. candida*; and it is here placed provisionally under *Candona*. Of course its specific relationship cannot be determined, for want of further evidence.

Note.—The *generic* relationships of all the foregoing species are for the most part uncertain, the hingement being very rarely indicated by exposure or definite outline.

EXPLANATION OF PLATE II.

(The figures are magnified 25 diameters.)

Fig. 1. *Candona candida* (Müller); *a*, right valve; *b*, edge view; *c*, end view.
Fig. 2. *Cytheridea Tyrrellii*, sp. nov.; *a*, left valve; *b*, edge view; *c*, end view.
} I. Rolling River. Pleistocene.

Fig. 3. *Pontocypris pyriformis*, sp. nov.; *a*, left valve; *b*, edge view; *c*, end view.	II. Loose block.	Saint-Mary-River Beds.
Fig. 4. *Cypris Dawsoni*, sp. nov.; *a*, left valve; *b*, edge view; *c*, end view.		
Fig. 5. *Ilyocypris oblonga*, sp. nov.; *a*, right valve; *b*, edge view; *c*, end view.		
Fig. 6. *Cythere*, sp. indeterminate. Two valves, imperfect.	III. North Branch, Milk River.	
Fig. 7. *Candona? Sanctæ-Mariæ*, sp. nov.; *a*, left valve; *b*, edge view; *c*, end view.		
Fig. 8. *Cytherella crucifera*, sp. nov.; *a*, right valve; *b*, edge view; *c*, end view.		
Fig. 9. *Candona* (?), sp. indeterminate. Dorsal aspect.	IV. Old-Man River.	

NOTICES OF MEMOIRS.

A Description of the so-called Salmonoid Fishes of the English Chalk. By A. Smith Woodward, F.G.S.[1]

Of English Cretaceous fishes three genera (*Osmeroides*, *Aulolepis*, and *Acrognathus*) are commonly assigned to the Salmonidæ. None have hitherto been described in detail, and the present paper is intended to give a full account of the osteology of the two first-mentioned genera, so far as the best specimens will allow. Nothing new has been discovered in reference to *Acrognathus*.

Osmeroides Lewesiensis is proved by several specimens in the British Museum to possess a large, though very thin gular plate between the rami of the mandible. The branchiostegal rays are numerous, and the opercular apparatus is complete. The marginal teeth are extremely minute and clustered in both jaws. The maxilla is arched, exhibiting a convex oral margin, and overlapped above by two large supramaxillaries, shaped as in the herrings. The parietal bones meet in the median line, excluding the supraoccipital from the cranial roof. Thin plates completely cover the cheek. Intermuscular bones appear to be present in the abdominal region.

The type skull of *Osmeroides crassus* (Dixon) is now described for the first time, and proved to be generically distinct from *O. Lewesiensis*. It has large, well-spaced conical teeth, and so much resembles the skull of *Elopopsis*, not hitherto recorded from the English Cretaceous, that the fossil may be provisionally assigned to this genus.

Aulolepis typus agrees with *Osmeroides Lewesiensis* in the possession of a large gular plate, the meeting of the parietal bones, the very small size of the teeth, and the form of the supramaxillaries. It is remarkable for the advanced situation of the pelvic fins, and for the prominent ridge produced by the "lateral line" on the scales of the caudal region.

In determining the systematic position of these fishes from the English Chalk, it is, of course, impossible to refer to the most

[1] Abstract of a paper read before the Zoological Society, November 20, 1894.

distinctive external feature by which Salmonoids can be separated from Clupeoids. The nature of the matrix would not admit of the preservation of an adipose dorsal fin, even if it were originally well developed. Three osteological characters of *Osmeroides* and *Aulolepis*, however, now made known for the first time, combine to suggest comparisons only in one direction, namely, with the modern genera *Elops*, *Megalops*, and their extinct allies. These characters are (i.) the union of the parietal bones mesially to the exclusion of the supraoccipital from the cranial roof; (ii.) the arched maxilla overlapped above by two larger supramaxillary bones; and (iii.) the presence of a large gular plate. It is true that although in the typical Salmonidæ the supraoccipital separates the parietals on the cranial roof, there are rare instances (e.g. *Thymallus*) in which the parietals are in contact throughout their length. Further, it is known that the double supramaxilla is not quite constant in the Clupeoides, Elopines, and their allies. It may also be argued that as Dr. Günther admits to the Clupidæ living fishes with a gular plate (*Elops*, *Megalops*), there is no reason for excluding from the Salmonidæ any primitive fishes which differ only from the living members of this family in the possession of such a plate. Nevertheless, so far as the present writer is aware, supramaxillaries of the form described above in *Osmeroides* and *Aulolepis* have not hitherto been observed in any Salmonoid, while they are the most common feature among Clupeoids and Elopines. The two Cretaceous genera under discussion may therefore be provisionally associated with the latter. The fishes named *Osmeroides* from the Chalk of Mount Lebanon may also be placed here, for they likewise exhibit a large gular plate; and *Elopopsis* is already assigned to the same systematic position by common consent. *Elops* and *Megalops*, indeed, have many more close allies in Cretaceous and early Tertiary strata than has hitherto been suspected, and the type they represent seems to have been dominant among the earliest Physostomi.

REVIEWS.

I.—The Great Ice Age and its Relation to the Antiquity of Man. By James Geikie, LL.D., D.C.L., F.R.S., etc. Third Edition, largely re-written. 8vo. pp. xxviii. and 850; Maps and Charts xviii.; Woodcuts 78, and Frontispiece. (London: Edward Stanford, 1894.)

THE long interval of seventeen years which has elapsed since the second edition of this work was published, must not be taken as an index that the subject of the "Great Ice Age" has during this period lost its interest with geologists or with the public generally, for the number of workers in this branch of geological investigation, and the amount of literature on it which is constantly appearing, seem to be alike on the increase, though not, perhaps, of late years so markedly in this country as in Germany and in the United States. Readers of this Magazine are well aware of the persistent frequency with which glacial subjects are brought forward

and discussed in its pages, and how divergent are the explanations given of the commonest phenomena. There still exist amongst us those who are able to combat skilfully with the pen in favour of such primitive views as the formation of Boulder-clay by cataclysmal deluges of water; who deny the capacity of glaciers to erode; and who advocate a portentously rapid elevation of mountain-ranges or the equally sudden submergence of large tracts of country to account for the destruction of one or two species of Mammalia. Views and opinions of this character are treated with scant notice by the author, and not deemed worthy of serious discussion, for he considers that they would long ago have been discarded by those pioneers in this branch of science who originally proposed them. The majority of present-day geologists will be likely to agree with the author in this matter, and they can afford to look with quiet indifference on the resurrection of these old-world views of a past generation.

A comparison of the present book with the edition of 1874 will give a very fair idea of the advances made, and the course and tendency of opinion on Glacial geology since this date. The author assures us that the general position remains the same, and that the additional evidence obtained confirms the view that there was an alternation of cold and genial conditions during the Glacial period, and that Man then lived in Europe. Following the lines laid down in the earlier edition, the character and succession of the glacial deposits in Scotland are first described at considerable length, and full particulars are given of the nature and origin of the Till or Boulder-clay, and of the striations and groovings on the rocks beneath it. Then, in a succession of chapters, the stratified and often fossiliferous beds subjacent to and intercalated with the Boulder-clays are considered, together with those beds which in many places overlie the Till. The question of rock-basins is next taken up, and then the probable formation of district ice-sheets and local glaciers, the relative position of the Arctic shell-beds, and the late Glacial and post-Glacial deposits of that country. Touching on glacial action in connection with the formation of the Boulder-clay, the author thinks that anyone now-a-days who has given the matter sufficient consideration must come to the conclusion that it is of glacial origin. Respecting the motion of glaciers, the theory of J. D. Forbes that it is due to the quasi-viscous or plastic nature of ice which moves down a slope by its own weight, is accepted as now established by the physical researches of late years, and on this point the experiments of M. Tresca are quoted, which show that the movements of ice under pressure do not fundamentally differ from those of any other solid under similar conditions, and that a mass of it a few hundred feet in thickness, with its temperature at or near the melting point, would, even if it rested on a horizontal plane, flow outwards in all directions until the shearing force came to counterbalance the pressure.

Summarising the evidence of the glacial and interglacial deposits of Scotland, the author gives a very striking picture of the geological

changes which he considers them to indicate. There is, first, the Lower Till or Boulder-clay, the ground-moraine of a *mer-de-glace*, which covered all Scotland to a height of 3500 feet. This ice-sheet united with the inland ice of Scandinavia on the bed of the North Sea, and the united masses swept even across the Orkney and Shetland Islands. (2) The *mer-de-glace* melted away, and an extensive land-surface was laid bare, on which a flora and fauna of a temperate character flourished. In many places there are fresh-water and marine deposits of this period which rest on the Lower Boulder-clay, and are covered up by an Upper Boulder-clay. Then depression of the land commenced; the submergence may have amounted to 500 feet, and it was accompanied by an Arctic climate. (3) Another *mer-de-glace*, probably less extensive than the first, spread over the country and produced the Upper Till or Boulder-clay. (4) During the melting of this second *mer-de-glace* the Kames and åsar may have been formed, and probably some of the glacial lakes of the Southern uplands. (5) The melting of the second *mer-de-glace* seems to have been followed by a prolonged interval of milder climate, but the evidence for this depends rather upon some of the continental deposits than upon anything preserved in Scotland. (6) A third period of glaciation set in, but this time the ice only formed district sheets and valley glaciers. There was a contemporaneous submergence to the extent of 100 feet, shown by the Arctic flora in the Marine Clays. The glacial lakes of Lochaber are attributed to this period, and the high-level gravel terraces of the larger river-valleys. (7) The land was again elevated; the climate became milder, and Scotland was covered with forests and inhabited by a temperate Mammalian fauna. (8) The Estuarine Deposits and the Raised Beaches of about 50 feet above the present sea-level, covered as they are in places by the terminal moraines of valley glaciers, indicate that the Forest period was succeeded by a colder and wetter climate, which was favourable to the growth of peat. (9) An Upper Buried Forest seems to show that the country had been again raised, and that there was a drier climate, and another period of forest growth. (10) A colder climate and a slight submergence of 25 to 30 feet is shown by another deposit of peat covering the upper buried forest, and by raised beaches. (11) The present period, in which the land is slightly higher again, and the climate probably drier.

As compared with the glacial succession in Scotland, given in the preceding edition, the above summary indicates with considerable confidence not only a greater number of climatic changes in which Arctic conditions alternate with temperate, but also a very regular series of depressions and elevations of the land, and the association of the Arctic climate in each case with the period of submergence and the genial climate with the period of elevation.

Passing on to the description of the glacial phenomena of England, the author treats first of the beds exposed on the Norfolk coast, at and near Cromer, from which had been obtained the only reliable evidence as to the kind of plants and animals that flourished

in England before the epoch of maximum glaciation. From the time of the Red Crag onwards, the number of northern forms of life continues to increase, whilst the southern forms die out, so that in the Chillesford and Weybourn Crags the Molluscan fauna has a thoroughly Arctic facies. On the other hand, the flora and fauna of the next succeeding Forest-bed series is of a temperate character, very similar to that which now prevails; and Mr. Clement Reid, who has so carefully worked out the Forest-bed flora, considers that it may have been contemporaneous in our area with the Arctic fauna of the Weybourn Crag. Dr. Geikie, however, does not think this probable, and favours the view that the Forest-bed was formed in a comparatively genial climate which succeeded the Arctic one of the Weybourn Crag. Be this as it may, there is no doubt whatever of the Arctic character of the climate which followed the period of the Forest-bed, as shown by the plants discovered by Nathorst in the overlying fresh-water bed, which indicate, according to Mr. Reid, a lowering of the temperature by about 20°. A still more severe period of cold accompanied the formation of the Cromer Till, the intermediate sands, gravels, and clays, and the contorted drift with which all geologists are so familiar. With respect to the "contorted drift," the author now regards it as a peculiar form of ground-moraine, in which masses of Chalk and different kinds of Pliocene and Pleistocene beds are jumbled together in the wildest confusion, and yet, curiously enough, this kneaded-up material usually rests with a horizontal junction on quite undisturbed beds. The intercalated beds of sand and gravel in the Boulder-clay series are attributed to the action of water flowing beneath the ice-sheet, and the author concludes that all the Pleistocene accumulations of the Cromer Cliffs are of glacial and subglacial origin, and belong to one and the same period of glaciation.

As to the succession of the glacial deposits in Lincolnshire and Eastern Yorkshire, Dr. Geikie agrees with Mr. Lamplugh that the Sewerby beach and the Speeton shell-bed are probably contemporaneous with the *Leda myalis* bed of the Norfolk cliffs, and that they were formed during mild conditions of climate before the advent of the great *mer-de-glace*, which crept in upon the land from the north-east, out of the bed of the North Sea, and produced the basement or lowest Boulder-clay. The Scandinavian erratics in this clay may have travelled all the way from their place of origin underneath the ice-sheet; the suggestion, which recently appeared in this MAGAZINE, that they had been transported as ballast in the Vikings' ships, is of too late a date to be noticed by the author. The formation of the purple clay, with its associated sands and gravels, has been referred by Mr. Lamplugh to the period of the retreat of the margin of the ice from Holderness. In this clay the erratics are more conspicuously of home origin. The marine gravels of Kelsea Hill are attributed to a later date, when the land had been submerged for 100 feet, and the presence of the Pleistocene Mammalia and of the fresh-water shell, *Corbicula fluminalis*, are accepted as proving an extended period of genial conditions since the time of the maximum

glaciation. The Upper or Hessle Boulder-clay indicates the re-appearance of a great *mer-de-glace* in the North Sea; the erratics in this clay are also evidently from British rocks, and they show that the ice-sheet hugged the coast and was prevented from flowing right out to sea by the presence of the Scandinavian ice.

Passing now to North-west England, Dr. Geikie still firmly maintains that the Boulder-clays of this district are the ground-moraines of ice that overflowed from the basin of the Irish Sea, and he now considers that the "Middle Sands," formerly thought to be high-level "marine drifts," are simply morainic materials carried upwards to their present position by an ice-sheet—a view suggested many years since by Goodchild and Belt, and strongly advocated by the late Professor Carvell Lewis and others. Under the same category of gravelly moraines are also placed the shelly gravels described by Mr Nicholson from near Oswestry at levels of 900 to 1160 feet above the sea. The sands and gravels which in the Midlands are so prominently developed, are regarded as the work of torrential waters during the melting of the ice-sheet. The evidence of interglacial beds in the maritime areas appears to indicate a submergence after the melting of the *mer-de-glace*, but its extent is quite uncertain—probably it did not go beyond 300 or 400 feet.

In an interesting chapter on the Drift Deposits of Southern England the author refers to the "rubble-drift" or "head," the origin of which has lately been attributed by Professor Prestwich to marine action, which swept the materials from higher to lower levels, whilst the land was being raised by comparatively rapid jerks from an imagined subsidence of 1000 feet under the sea. As no trace of a marine origin is shown in these deposits, and there is no direct evidence of the presence of the sea, this hypothesis is by no means convincing. A more probable explanation is that the angular drift of the "head" has reached its present position by the action of frost and melting snows, and the gradual forward movement of saturated, thawing subsoils. It is reasonable to suppose that at the time when the country north of the Thames was entirely covered by an ice-sheet, the climate of the Southern districts was sufficiently severe to have frozen the surface soil to some depth, and to have allowed the accumulation of snow, and perhaps of thin fields of ice, and by the melting of these deposits in the summers whilst the soil was frozen, the present dry valleys in the Chalk might have been eroded and beds like those of the Coombe-rock formed, as suggested by Mr. C. Reid.

Want of space prevents us from commenting on the author's description of the glacial phenomena of Northern and Middle Europe, of the Alpine Lands, and other portions of the Continent; but the summary of this portion of the subject lays open so clearly the succession of events which the evidence is considered to have established that we venture to give a condensed version of it.

I. Pre-Glacial Times. In the older Pliocene the sea, which then covered considerable portions of the east and south of England and parts of Belgium, Holland, and France, was tenanted by a fauna

indicating a genial climate. As time passed, the Southern forms disappeared, and were replaced by Northern types.

II. First Glacial Epoch. An Arctic fauna lived in the North Sea. The basin of the Baltic was occupied by an immense glacier. Glaciers also descended from the volcanic mountains of Central France, and the mountain valleys of the Alpine Lands were filled with ice which heaped up moraines on the low grounds. To this epoch belong the Weybourn Crag and the Chillesford Clay.

III. First inter-Glacial Epoch. The Arctic fauna retreated from the North Sea, and the southern part of it was now dry land, across which the Rhine and other rivers flowed. The flora was comparable to that now existing, and the Hippopotamus, Elephants, and other Mammals lived in this country. The period of the Cromer Forest-bed. Subsequently the temperate flora in England was replaced by Arctic forms.

IV. Second Glacial Epoch. An enormous *mer-de-glace* covered all the northern part of Europe, and reached as far south as Saxony. Arctic-alpine plants occupied the low grounds of Central Europe, and northern animals lived round the shores of the Mediterranean. To this epoch belong the Lower Boulder-clays and associated fluvio-glacial deposits of this country.

V. Second inter-Glacial Epoch. A temperate and southern flora took the place of the Arctic-alpine on the low grounds. The plants growing at this time in North Germany and Central Russia, indicate a climate milder than the present one in those regions. Hippopotamus and *Elephas antiquus* are included in the Mammalian fauna. Britain was connected with the Continent, and there was probably a land bridge between Europe and Africa. The Hessle gravels, Sussex beach deposits, etc., were probably formed in this period. Its long duration is shown by the depth to which the river-valleys were eroded.

VI. Third Glacial Epoch. Another extensive ice-sheet covered the greater part of the British Isles and a large area of the Continent, but it did not reach so far as the previous one. The glaciers of the Alps reached to the low grounds, and formed the moraines of the "inner zone." To this period are assigned the Upper Boulder-clay and its associated fluvio-glacial deposits.

VII. Third inter-Glacial Epoch. Temperate conditions, the evidence for which is principally derived from the youngest inter-Glacial beds of the Baltic coast-lands. Much of the old alluvial deposits of Britain and Ireland probably belong to this period, though hitherto classed as post-Glacial. Some of the beds in the Baltic area contain the remains of Mammoth, Woolly Rhinoceros, Horse, Irish Deer, and Urus.

VIII. Fourth Glacial Epoch. In the early stages Scotland was submerged to the depth of at least 100 feet, and an Arctic fauna lived in the sea. Glaciers came down from the mountains and filled the Highland fiords. The snow-line did not reach higher than 1000 or 1600 feet above the sea in Scotland. Another ice-sheet covered the Scandinavian peninsula, and the glaciers from it

occupied the fiords of Western Norway. The Baltic basin was filled by an ice-stream which extended over North Germany and Denmark. Subsequently a wide area in Scandinavia was submerged in a cold sea. Large glaciers reached a long way down the Alpine valleys, but not so far as in the preceding Glacial epoch.

IX. Fourth inter-Glacial Epoch. At its climax, the conditions were sufficiently temperate to allow of the growth of forests in northern regions where they cannot live at the present day. Britain was united with the Continent and the Baltic was changed into a great lake.

X. Fifth Glacial Epoch. The coast-lands of Scotland were submerged to about 50 feet below their present level; local or valley moraines were formed in the British Isles, and their position indicates that the height of the snow-line was then about 2500 feet. Most of the corrie rock-basins of the British Isles may be assigned to this period. In the Alps the epoch is marked by the moraines of the so-called "second post-Glacial stage."

XI. Fifth inter-Glacial Epoch. An elevation of the land took place and the valley glaciers retreated. The upper "buried forests" in the peat-bogs of North-west Europe show that the climate was drier and very favourable to forest growth.

XII. Sixth Glacial Epoch. The later raised beaches indicate a slight submergence, not exceeding 20 to 30 feet, in Scotland. The climate was more humid and more suitable for the growth of peat than of forests. The snow-line in Scotland was at an elevation of 3500 feet.

XIII. The Present. Distinguished by the retreat of the sea to its present level, milder and drier climate, and the final disappearance of permanent snow-fields.

As in the case of Scotland, the above summary of the succession of events during the Ice Age in Europe generally, brings before us so many alternations involving radical changes of climate and repeated advances and retreats of the sea, that the question will naturally arise whether the fresh evidence gained during the last seventeen years is sufficient to support the idea that such a marvellous series of changes can have taken place in such a limited period of geological history. Looking back to the edition of 1877, we there find that the glacial deposits of Europe were considered to indicate *two periods* of intense glacial conditions, and that during the first of these there was a subordinate interval of milder climate, and a more strongly marked milder period—called the last inter-Glacial—intervened between the two severe Glacial periods. Now, however, an alternate succession of no fewer than *six Glacial* and *five inter-Glacial* epochs is put before us as the latest interpretation of the evidence. But even accepting the important additional evidence resulting from the more detailed study of the glacial deposits of Northern and Central Europe, it seems to us insufficient to establish that multiple succession of boreal and temperate epochs which is pictured to us as recurring, see-saw fashion, during the later portion of the Ice Age.

Treating of the "Valley Drifts," Dr. Geikie comments on the investigations of M. Ladrière in the river valleys of France and the North of Belgium, and considers that they throw great light on the characters of the valley drifts of the Thames. He questions the soundness of dividing these latter into an older high-level and a younger low-level series, and thinks that it is only the bedded gravels of the lower levels which are positively of fluviatile origin; the high-level loams and angular gravels which extend upwards to the plateaux are more probably local formations like the similar accumulations in Northern France. If those primitive implements, discovered by Harrison at the high-levels on the Chalk plateau of Kent, should be proved eventually to belong to the same age as the Plateau-drifts, the human period would date back to a much earlier period than has hitherto been dreamed of.

Reference is also made to the ice-cliffs on the shores of Northern Alaska, described by Dall, which form part of a broad ridge of ice about two miles in width and 250 feet high. Overlying this ice-rock is a bed of clay containing the bones of Mammoth, Horse, Elk, Reindeer, Musk-Ox, Bison, and Big-Horn. The author supports Dr. Penck's explanation that this ice-sheet must date back to Pleistocene times, and that it has the same origin as the frozen bottoms or grounds so commonly met with in the higher latitudes of North America and Asia. This dead ice-sheet, which is now wasting away, must belong to a period when the climate of those regions was much colder than at present. It is not the relic of any glacier, but it probably results from the accumulation of drifted snow in Glacial times.

Touching the period of the first appearance of Palæolithic Man in the European area, Dr. Geikie does not consider that we have unequivocal evidence of his presence until the second inter-Glacial epoch (*Elephas antiquus* stage), when he is characteristically represented by the Chellean or St. Acheul type of flint implements so common in the old river-gravels of the Thames and the Seine.

Two chapters, containing a very graphic description of the Glacial phenomena of North America, have been written by Prof. T. C. Chamberlin, who has taken a leading part in the study of the deposits of the Ice Age on that continent. Drift deposits are estimated to cover nearly one-half the area of North America, which means that the glaciers of the Ice Age spread themselves over about 4,000,000 square miles of territory. The main body of ice, appropriately called the Laurentide Glacier, probably originated in more than one centre in Labrador, and in the region north-west of Hudson's Bay, and the nuclei grew until their borders coalesced and the Hudson basin became a great reservoir of ice, from which issued the streams or sheets which covered the eastern five-sixths of the Dominion of Canada, and the larger part of sixteen of the Northern States of the Union and smaller portions of even others. The most southern point reached by the *mer-de-glace* was in the State of Illinois, between the Ohio and the Mississippi rivers, in lat. 37° 35′.

Prof. Chamberlin represents the Drift deposits of the great plain region of North America as a series of sheets overlapping each other in intricate fashion, and in this case only that outer zone or margin of each sheet which was not reached by the one next succeeding, retains its original form (except as modified by superficial agencies), whilst the inner buried zone was liable to much alteration by the over-riding ice of the later advances. It ought to be remembered that the outermost zone of deposits, which are called the earliest for convenience sake, are really those of maximum glaciation—the mid-winter of the Glacial period. The extent of the imbrication of the glacial deposits largely depends on the oscillations of the ice-margin and the intensity of the ice-action. If the ice-margin, in its advance, pushed forward all the loose *débris*, there would remain a series of concentric moraines instead of the imbricated sheet.

The constituents of the Drift deposits in North America closely resemble those of Europe. The Till or Boulder-clay is precisely similar in character. Individual sheets of it have an average thickness ranging from 20 to 60 feet; its maximum thickness in a few places is known to exceed 500 feet. Terminal moraines are truly of gigantic size: some have been traced for several hundred miles in individual distinctness. The chief of the complex belt of moraines has been followed from the Atlantic coast over the Appalachians, across the broad Mississippi basin, and then far out upon the North-western plains of Canada, and it may possibly have reached to the Arctic seas. The other products of glacial action, such as Drumlins, Åsar, Kames, Glacio-fluvial Aprons, Valley Drift, and Löss are also represented on an enormous scale.

Professor Chamberlin has tentatively proposed to subdivide the glacial deposits of North America. The lowest sheet is named the Kansan formation from the fact of its reaching as far as what are now the dry hot plains of Kansas, 1500 or 1600 miles distant from the centre of the radiation of the ice-sheet. This lowest deposit is essentially of Till, with assorted beds of sand, clay, and gravel.

The Kansan formation is followed by a later drift, named the East-Iowan, but between these two there is a well-developed soil-horizon, consisting of peat, logs, twigs, stems, and other vegetable *débris*, in which have been recognised remains of pine, oak, elm, sumach, walnut, ash, and hickory trees, with bones of *Equus*, *Lepus*, and *Mephitis*. Overlying the East-Iowan formation is a second horizon of soil and plant accumulations, and this in its turn is overlapped by a very marked glacial drift, the East-Wisconsin formation, the outer margin of which is formed by a distinct terminal moraine, usually one to five miles wide, and from 50 to 300 feet thick. The retreat and melting back of the ice resulted in the formation of immense lakes.

Very various opinions are held by American geologists as to the chronological interpretation of these various formations; some maintain the view of two periods of glaciation and two intervals of deglaciation; but there is a growing disposition amongst field workers to recognise three distinct Glacial, and as many inter-Glacial

epochs. It would obviously be premature to attempt at present to correlate the glacial succession in North America with that in Europe, but the fact of important climatic oscillations during the Ice Age is as clearly shown in the former country as in the latter.

In this edition the consideration of the cause of the Climatic and Geographical Changes of the Glacial period forms the final chapter of the book. The author still holds that the astronomical theory of the late Dr. Croll appears the best solution of the Glacial puzzle, as it accounts for all the leading facts; for the occurrence of alternating cold and warm epochs, and for the peculiar character of Glacial and inter-Glacial climates, and further, it postulates no other distribution of land and sea than now obtains. This theory has undoubtedly thrown a flood of light upon the difficulties of the subject, and it may be that some modification of his views will eventually clear up the mystery.

This third edition of the "Great Ice Age" should be received by those interested in the study of Glacial Geology with as warm a welcome as that which was accorded to the first edition twenty years ago. Opinions will differ respecting some of the generalisations of the author, but all will agree on the value and importance of having the evidence on this subject brought down to date, and stated in a clear and impartial manner. G. J. H.

II.—The Life of Richard Owen.[1] By his Grandson, the Rev. Richard Owen, M.A. With the Scientific portions revised by C. Davies Sherborn. Also an Essay on Owen's Position in Anatomical Science by the Right Hon. T. H. Huxley, F.R.S. 2 vols. 8vo. Pp. 409 and 393, with Portraits and Illustrations. (London: John Murray.)

THE record of the life of so well known a man as the late Prof. Owen cannot fail to be of great interest, not only to those to whom his researches more especially appeal, or who have known him as a friend, but also to the more general reader. For Owen, although a scientific man whose province was principally that of Comparative Anatomy, and perhaps more especially that of Vertebrate Palæontology, was at the same time a man of very broad human sympathies, and devoted a large amount of his earlier life to the services of his fellow-men by acting on various hygienic commissions; he was further very successful both as a popular and a special lecturer; finally, by his efforts as Hunterian Professor at the Royal College of Surgeons, and afterwards as Superintendent of the Natural History Departments of the British Museum, he did more than any of his predecessors to bring the study of Natural History before the public, to force its recognition on, and obtain its continual support from, the Government. It is hardly an exaggeration to say that Owen was the most popular and widely known of all the scientific men the present century has seen.

These records consist of letters and extracts from the diaries of

[1] For an Obituary of Owen, accompanied by an excellent portrait, see Geological Magazine, 1893, Decade III. Vol. X. p. 49.

Prof. Owen and his wife, more especially from that of the latter, who, it appears, kept a most exhaustive account of all Owen's doings and work. It is delightful to notice what deep interest she took in all his researches, and how carefully she recorded their progress; and the fact that she did not complain even when the house was occupied by a defunct Rhinoceros or portion of an Elephant sufficiently hung to necessitate keeping all the windows open, shows that she was a most sympathetic wife for a scientific man.

Vol. I. commences with Owen's ancestry, and his early training at school and at home; his letters to and from his mother and sisters show what a lovable man he was. It is amusing to read of his having been stigmatized while at school as "lazy and impudent": what would that master think of his forecast if he could read these volumes? We find an interesting account of his early taste for ethnology in his adventure with the negro's head (page 23) during his apprenticeship to a surgeon at Lancaster. But it was not until he went to Edinburgh, where he founded the Hunterian Society, that his scientific inclinations were really manifested. From Edinburgh, acting on the advice of Barclay, he came to London to study at St. Bartholomew's under Abernethy, and it was owing to the recommendation of the latter that he was appointed Assistant Curator of the Hunterian Collection at the Royal College of Surgeons.

It is from this date (1826) that Owen's career as a scientific man commenced, and the greater part of Vol. I. is devoted to his life at the College of Surgeons. This is, perhaps, the most interesting part of the work, for we are able to trace how he gradually weaned himself from medicine and devoted himself more and more to comparative anatomy, due in the first place to the nature of his work, and also, probably, in a large manner to the unconscious influence of the great scientists with whom he came in contact. One of the earliest of these was Cuvier, who visited the College and invited Owen in return to Paris. His biographers evidently consider that the supposed influence of Cuvier on Owen's future work has been overestimated, but, as Huxley points out, Cuvier's work stands out so pre-eminently when compared with that of his contemporaries that it must have had considerable influence in directing the method of work of a young aspiring anatomist such as Owen then was, and the mere fact that no reference of such influence is recorded in Owen's diary goes for nothing.

It is perfectly marvellous to note the amount of energy which Owen must have possessed, for we read of his working all day at his catalogues, his dissections, his lectures, and his duties on various Commissions, then winding up the day with theatres or concerts, and commencing the next by sitting up to write scientific papers or, sad to relate! to consume novels.

During the thirty years of his connection with the College of Surgeons, the most important of Owen's scientific work was done; and we are here able to read of the rapid growth of his now world-wide reputation as an Anatomist and a Palæontologist. Here, too,

we read of his social intercourse with all the celebrated men of those days. To the general reader this portion will especially appeal, for here we find interesting letters and anecdotes of Turner, Carlyle, Dickens, and many more distinguished men in every branch of life.

In the second volume we come to Owen's connection with the British Museum, and a special chapter is devoted to the account of his efforts and ultimate triumph in the removal of the Natural History Collections to a special building. Here are reproduced Owen's original plan and Waterhouse's first modification of the same; in both of these we recognise a building intended to serve primarily as a Museum but also provided with lecture theatre and teaching collections. How the present architectural structure, devoid of so many of the best features of the original design arose, is not explained.

Appended to the second volume is an interesting account tracing the development of Anatomical Science, and Owen's relation to the same, by Prof. Huxley. This is written in such a manner that it may be easily followed by the non-scientific reader. It seems a pity, for the sake of the latter, that this was not rather placed as an introduction to Vol. I.

The perusal of this work by the public would do much to dispel the favourite representations of scientific professors being necessarily dry old bores, for Owen was one of the most charming of men, and, in addition to his great qualifications as a scientist, was pre-eminently calculated to shine in society. The recognition of his social qualities may be seen all through his life, both by Royalties and Commoners; and we find him being entertained by the Prince of Wales, and on other occasions by his fellow scientists, at social meetings where every kind of "ology" was barred.

The two volumes contain some charming portraits of Owen, especially the frontispiece to the second volume; there are also illustrations of Owen's most important discoveries. As an Appendix we find a most imposing list of his distinctions, and a complete Catalogue of his works, numbering in all about 650. M. F. W.

III.—The Permian Fishes of Bohemia.

Fauna der Gaskohle und der Kalksteine der Permformation Böhmens. By Prof. Dr. Anton Fritsch. Band III. Heft 3. Pp. 81–104, Pls. 113–122. Prague, 1894.

DR. ANTON FRITSCH has just issued another part of his well-known work on the Bohemian Gas-coal (Lower Permian). For some time he has been treating of the fishes, and now he is well advanced in the description of the Palæoniscidæ. The present instalment is as exhaustive as ever, and we cannot but admire the care with which the author turns to good use even the most fragmentary specimens.

Before treating of undoubted Palæoniscidæ, Dr. Fritsch places a section "Incertæ sedis" to which he assigns an imperfectly known fish under the name of *Acentrophorus dispersus*, sp. nov. If the

generic determination of the species be correct, as seems likely, there need be no hesitation in referring it to the Semionotidæ to which the typical English species undoubtedly belong; but the hinder half of the Bohemian fish still remains to be discovered.

The description of the Palæoniscidæ is prefaced by von Zittel's definition of the family, and a translation of the Synopsis of the known genera given in the British Museum Catalogue of Fossil Fishes. The difficulty of recognising some of the characters mentioned in this Synopsis is also briefly remarked upon. It would have been more satisfactory, however, if Dr. Fritsch had likewise been able to discuss the still more difficult question of the genera of Palæoniscidæ described by Dr. Sauvage from the Permian of France, which may be assumed to have their counterparts in Bohemia. Perhaps this subject is reserved for the general chapter on the Palæoniscidæ, which is wisely postponed until the detailed descriptions of the Bohemian Permian genera and species are completed.

The new generic name *Pyritocephalus* is proposed for a small species previously recorded as *Palæoniscus sculptus*. It belongs to the group to which *Canobius* and *Amblypterus* are referred, and is remarkable for the close ornamentation of the head with large raised lines of ganoine. The fins are small, the dorsal opposed to the anal; and the scales are smooth, not deepened on the flank.

Another fish described as a new genus, and one of the greatest interest, is *Sceletophorus*, with the single species *S. biserialis*. This, too, is an Amblypteroid, but with very thin serrated scales and no fulcra even on the median fins. A few rounded scales immediately above the pectoral fin are described, and remains of the axial skeleton in the abdominal region are interpreted as displaying elongated ring-vertebræ. If this view be correct, Palæoniscidæ are shown for the first time with completed vertebral centra. We believe, however, that the "wirbelröhre" are merely the crushed bases of the neural arches through which the spinal chord passed (for they are no larger than the canal of the lateral line of the same fish); and in the specimen figured (pl. 116, fig. 1) the small hæmal elements may well be regarded as displaced upwards over the open space originally occupied by the notochord. Another fish, which Dr. Fritsch thinks may possibly prove to be the young of a species of *Sceletophorus*, is provisionally assigned to *Phanerosteon* under the name of *P. pauper*. This has scales only on the upper caudal lobe, and also displays traces of the endoskeleton, which are supposed to include hollow cylindrical vertebral centra. Here, again, the cartilages in question are disproportionately small, but the drawing does not enable us to make any suggestion as to their true nature; we can only regard them as much too problematical to be used for modifying current views as to the nature of the vertebral axis in the Palæoniscid fishes.

Amblypterus itself follows, and Dr. Fritsch decides to adopt the comprehensive definition of the genus first suggested by Traquair. He points out, however, that the numerous species can be arranged

in groups which are respectively confined to different geological horizons. *Amblypterus Kablikæ* is first discussed, and this seems to be confined to the highest stratum of limestone in the Bohemian Permian. A new species, *A. verrucosus*, is then described as the earliest known Bohemian Palæoniscid. This is closely related to *A. Duvernoyi*, which next receives a brief notice. Dr. Fritsch doubts the advisability of assigning to the latter form as many so-called species as some previous authors, and points out the comprehensive character of the diagnosis of *A. Duvernoyi* in the British Museum Catalogue. He concludes the present "Heft" with an account of the form commonly known as *A. Vratislaviensis*, and begins a similar description of *A. Rohani*.

A glance over Dr. Fritsch's drawings will well repay the ichthyologist and anatomist; and the careful manner in which the different fossils are compared renders the work of equally deep interest to the geologist. We can only conclude by congratulating the Director of the Royal Bohemian Museum on the fact, that even the absorbing duty of arranging his new cases and exhibition galleries does not interfere with the progress of his great contribution to Palæozoic Palæontology. A. S. W.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—November 21st, 1894.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "The Pleistocene Beds of the Maltese Islands." By John H. Cooke, Esq., F.L.S., F.G.S.

For the right understanding of the Pleistocene beds, a previous knowledge of the physiography of the islands and of the earlier sediments is necessary. A full description of the physiography and of the character of the sediments, so far as they are necessary for the understanding of the accumulations forming the subject of the paper, occupies its earlier portion. Especially noticeable is the absence of ordinary anticlinal and synclinal folding, and the predominance of monoclinal faults, which largely affect the character of the surface. These faults were formed prior to the deposition of the Pleistocene beds.

The plateaux of Malta, rising to a height of 600—800 feet above sea-level, occur south of the great east-and-west fault, which has a downthrow to the north. They have no Pleistocene deposits upon their summits.

Three classes of superficial deposits are described:—

(*a*) Valley-deposits, including (1) those found on the higher slopes of plains and plateaux, due to subaërial waste and rain-action, containing land-shells and mammalian bones; and (2) those situated at the bottoms of valleys, consisting of stratified layers of water-worn sand, gravel, and large pebbles, occurring in such order as to show that the agents which produced them have greatly decreased in intensity.

(*b*) Agglomerates and breccias found along coast-lines and fault-terraces, always at the foot of the fault-terraces, or along the lower slopes of the depressed areas: these accumulations are either submerged or lie at the water-line. Their materials are much water-worn, and land-shells are contained in many of the layers. The agglomerates are in many cases distinctly stratified; and the author concludes that the materials appear to have been swept down, during heavy rainfall, into the waters of land-locked creeks.

(*c*) Ossiferous deposits of caves and fissures, which have been described elsewhere.

2. "Geological Notes of a Journey in Madagascar." By the Rev. R. Baron, F.L.S., F.G.S.

The part of the island travelled over may be divided into four sections.

(*a*) *Antananarivo to the East Coast.*—The principal rock is a hornblende granitite-gneiss, but there is also much norite usually containing olivine. The general strike of gneiss and norite along this region is north-west and south-east, or north-north-west and south-south-east. The country is traversed by several large dolerite-dykes.

(*b*) *The Northern Part of the East Coast.*—Dolerite-flows predominate along the coast, and from their character are believed to have flowed from such fissures as are indicated by the dolerite-dykes noted in the preceding section. Some felsites, probably lavas, and felsitic breccias were also observed; also a granitite penetrated by epidiorites, and associated with chiastolite-slates. Many other rocks, schists, and eruptives were found.

(*c*) *The Northern End.*—Sedimentary rocks (sandstones and limestones) are extensively developed in this section, as well as much volcanic material. The sediments are of Jurassic and Cretaceous ages. The volcano Ambohitra is situated on these sediments, and has poured out olivine-basalts. Shells of recent species occur on the mountain-chain at the northern end.

(*d*) *The North-western Coast and Islands.* — Marine strata of Jurassic, Cretaceous, and Eocene ages are found in this area, together with various igneous rocks including trachyte, foyaite, nepheline-phonolite, hauyne-nepheline-phonolite, andesite, and basalt. South-west of Anorontsanga are four islands—three composed of volcanic rocks, and the fourth, Antanifaly, of nummulitic limestone.

3. "On a Collection of Fossils from Madagascar obtained by the Rev. R. Baron." By R. Bullen Newton, Esq., F.G.S.

The fossils forming the subject of this paper were collected in the northern part of the island. The author gives an account of the previous work on the fossils of Madagascar; this is followed by a description of the post-Tertiary, Tertiary, Cretaceous, and Jurassic fossils. The post-Tertiary fossils are for the most part terrestrial shells found on Ambohimarina hill, mainly of species still existing on the island. A few marine forms have been found elsewhere.

A description of species, many of them new, follows; and the

author furnishes a list of all recognized fossils from the island, concluding with notes on certain limestones, including a *Globigerina*-limestone and one containing *Girvanella*.

II.—December 5th, 1894.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "Supplementary Note on the Narborough district (Leicestershire)." By T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S., Professor of Geology and Mineralogy in University College, London.

The author revisited this district, briefly described by himself and Mr. Hill in 1878, at Easter 1893, and in September 1894. The old excavations had been greatly enlarged, but little of importance had been disclosed: no dykes and no new junctions with sedimentary rocks. But the crystalline rocks have been recently struck in a fresh locality between Narborough and Huncote, about half a mile west of the pit near the former village. As in that case, the rock lay very near to the surface; here the highest part of the boss was barely covered. The rock is hardly to be distinguished from that of the Narborough pit. The enlargement of the pit south of Enderby has exposed fresh sections of the junction of the slate and syenite, which has been now traced along the whole length of the pit from north to south, and some particulars are added to the former description.

The enlargement of certain of the pits has displayed some interesting sections of Boulder-clay resting upon the crystalline rocks. The latter are not appreciably ice-worn. The fragments in the Boulder-clay, identified by the author, were from the Carboniferous, Trias, Jurassic (especially Lias), and Upper Cretaceous formations. They indicated, in the main, a drift from a more or less north-easterly direction.

2. "The Tarns of Lakeland." By J. E. Marr, Esq., M.A., F.R.S., Sec.G.S.

The author has examined several tarns of the English Lake District. In those cases where the stream issues from the tarn over solid rock, he finds either (1) direct evidence that the tarn results from the blocking up of part of a pre-existing valley by drift, causing the deflection of the water to a direction different from that of the original stream in this locality; or (2) evidence which is perfectly consistent with such an explanation of the origin of the tarn.

Under the circumstances he would submit that tarns cannot be assumed to lie in rock-basins simply because the issuing stream flows over solid rock (and this assumption has been made), but that those who maintain the existence of such rock-basins must prove the occurrence of solid rock entirely around the tarn.

3. "Description of a New Instrument for surveying by the aid of Photography, with some Observations upon the Applicability of the Instrument to Geological Purposes." By J. Bridges Lee, Esq., M.A., F.G.S.

The instrument described in this paper consists essentially of a photographic camera fitted inside with a magnetic needle, which

carries a vertical transparent scale divided and numbered to 360°, and also with cross fibres which intersect at right angles. The fittings and adjustments of the instrument are of such a character that the camera can be accurately levelled and directed towards any point in a horizontal direction, and when a photograph is taken in an ordinary way the bearing of the median vertical plane, which bisects the instrument through the photographic lens, will be recorded automatically on the face of the photograph.

The vertical fibre (and its image on the photograph) serves as an index to read the bearing; and the same fibre marks, by its shadow, a line right across the photograph, which marks the median vertical plane on the image.

The horizontal fibre is adjusted to mark on the image the horizontal plane which bisects the photographic lens.

The camera rests on a divided horizontal circle, which can be adjusted to a truly horizontal position by levelling-screws. There is a tripod stand and head, with suitable appliances for supporting and adjusting the instrument in position. The camera is provided with a rectilinear doublet lens and iris diaphragm and rack-and-pinion focussing adjustment. It is made of aluminium, and it is surmounted by a telescope adjustable in altitude and fitted with vertical and horizontal webs; and it is also surmounted by a revolvable tubular level.

The details of construction and the peculiar features and adjustments of the instrument are fully described in the paper, and some of the chief purposes to which it may be applied in furtherance of geological research are pointed out.

4. "The Marble Beds of Natal." By David Draper, Esq., F.G.S.

A "crystalline limestone of enormous thickness" was mentioned by Mr. C. L. Griesbach, in 1871 (Q. J. G. S. vol. xxvii. p. 56), as occurring along the lower course of the Umzimkulu, in the county of Alfred in the southern part of Natal. Since the time of his visit there the country has been opened out by settlers, and some attempts have been made to utilize this marble. The chief mass of this rock is met with at about seven miles inland, in the Indwendwa hill-range, within the fork formed by the junction of the Umzimkulu and the Umzimkulana, over 700 feet above sea-level, and continuous with the tableland westward. This consists of granite, overlain with the massive marble, roughly stratified, which is denuded north and south of the hill, into the gorges of the two rivers, and is continued on the opposite flanks until cut off by faults. The north fault divides it from the Table-mountain Sandstone lying on clay-slate; and the south fault divides the granite from the Table-mountain Sandstone and clay-slate. The bedding of the marble dips towards the rivers on each of their flanks, and strikes E. and W.

In quality the marble varies from coarse to fine-grained, and in colour from pure white to deep red. The coarse-grained variety contains 5 to 13 per cent. of carbonate of magnesia. Calcareous tufa, in some places several feet thick, has been formed from the marble.

From the junction of the two rivers eastward, slate is seen below Table-mountain Sandstone; and on the latter is a long stretch of the Dwyka Conglomerate to the coast, greatly disturbed for the most part, and pierced by two dolerite-dykes, between which a patch of Ecca Shales is preserved.

The author concludes that the marble was deposited on the granite, and probably on the Malmesbury Slates near by, before they were disturbed; that it does not extend far under the neighbouring hills; and that some of its local detritus indicates that the rivers ran at higher levels within relatively recent times.

CORRESPONDENCE.

MR. DEELEY AND MR. HARKER: "TWO BIRDS WITH ONE STONE."

Sir,—In my view there is no more profitable way of advancing knowledge than by good-humoured controversy. I only wish my opponents' banter was a little more playful. Mr. Deeley is mistaken in supposing that I, of all people, can object to his attacking old problems. What I called impertinent, was attacking *very old problems* without first learning what other men had had to say to them, coupled with the assumption that the long life's-work of such patient masters of their craft as Studer, and Forbes, and others in the Alps, was going to be all set right by Mr. Deeley's summer jaunt to Mont Blanc.

What they proved and what recent experiments in the laboratory have confirmed is the plastic nature of glacier ice. Mr. James Geikie, who formerly advocated Croll's transcendental theory of ice-motion, has completely abandoned it in his new volume on the Ice Age, in favour of Forbes' view. Mr. Deeley, some time ago, had a private transcendental theory of his own on the subject, which I cannot find that anybody understood, much less adopted. I do not know whether he still holds to it, or is now satisfied by the experiments of McConnel, Kidd, and others, that Forbes was completely right. I take it from some phrases he uses that, like Mr. Geikie, he, too, has surrendered. If he has not, we are beating the air, for I am bound to say I neither understand the physical nor the mechanical basis of his ice theory.

If he now holds, as all the world holds, that ice is a viscous body, then he must also hold that it acts like one, and that when it has a sloping back it will not move at all on account of the shearing resistance of the ice, unless the slope of its back is equal to that of a glacier-bed when motion first ensues in a glacier. Forbes showed that this meant a considerable slope. The question for Mr. Deeley (entirely apart from all geological difficulties) is how to secure and maintain such an ice slope as would carry boulders to Britain from the Christiania Fjord, and then move on till it terminated in a scarped cliff of ice at the 100 fathom line, and this when the upper part of the Dovrefelds was entirely free from ice as it now is from markings. This is one only of a dozen difficulties surrounding an ice hypothesis which has been evolved apparently without any thought of the

critical problems which have to be met at every turn. To those whose geological and mechanical reasoning follows the same groove as my own, it seems impossible, as it seemed impossible on the same grounds to Pettersen, to Bonney, to Matthieu Williams, and to Milne-Holme, whose experience of glacial phenomena, combined with a knowledge of Western Norway and Eastern Britain, entitle them, I think, notwithstanding Mr. Harker's sneer, to the very first rank as authorities on the geological side of this particular issue.

I have argued the case out in detail in my book on the "Glacial Nightmare," at which I sincerely wish Mr. Deeley would look before advancing arguments which have all been answered by anticipation.

Mr. Deeley's reference to the Antarctic ice, which also occupies a considerable space in my book, seems to me entirely beside the question. The Antarctic ice, in so far as we have evidence, is planted on a high plateau of land. When it reaches the sea it does not march on as the Norwegian ice-sheet is supposed to have marched on, athwart the deep Norwegian channel, and then across the North Sea to the 100 fathom line, and there expose a great cliff, but it breaks off into icebergs *in shallow water*, and these icebergs float away. All this is perfectly rational. How it in any way supports the North Sea monster I know not. In the one case the ice behaves like other ice; in the other case it would behave, it seems to me, as no ice ever behaved before or since, except in a geological nightmare.

I will now turn to Mr. Harker. Although he affects to despise the virtue of modesty, he says "he has not written a word on the Scandinavian ice-sheet, and has kept his views on that subject modestly to himself." Is this so? In the Transactions of the Yorkshire Geological Society, where he discussed the question of these boulders at length, he distinctly refers them to Scandinavia, and actually says, "*the movements of the ice*, and the consequent directions of transport, render this conclusion probable." I think, after this, he ought to have called the boulders not "damaging" but "damaged."

If Mr. Harker no longer believes that ice brought the boulders from Scandinavia, then *cadet quæstio*. To disprove that hypothesis was the purpose of my writing. To be coy in making a confession on such a point after what he has written is to borrow a weapon from another sex than ours. We are not striving for some rhetorical advantage, but for the truth, and the truth is not served by carefully putting under a bushel the light that we may possess, and taking refuge in struthious logic. The question between us is, how are we to account for the Laurvig boulders? I suggested as a possibility that they may have been partially ballast, and partially stones used as anchors, net-weights, etc.

Nothing that Mr. Harker has yet said seems, to me, to have reduced the probability of that suggestion, *and it is only a suggestion.* He asks me whether the Vikings "ballasted their ships with little pieces of rhombenporphyr, and used small pebbles of laurvikite for

anchors." Is this supposed to be argument? If Mr. Harker thinks that the big stones, which were on the beach a thousand years ago, when the Vikings were about, have not been ground into small ones by this time, he is probably singular in his views, but apart from this most ballast is simply gravel. He next alleges the fact that the sea is invading the land on this coast. How the fact that the coast is a retiring coast affects the relative position of the beach as between high-water and low-water I know not. Does Mr. Harker think that when the sea invades the land, to the extent of a hundred yards, say, it leaves its old beach behind. Again, he says, "there is no *port* in Holderness": what has that to do with it? It was probably because there was no port there that the whole fleet of pirate ships which attacked Northumbria in 793 was lost on this very coast, and that many others were similarly lost at other times. Again, he bids me remember that a couple of the boulders in question were found at Cambridge. This I learnt after I wrote my first paper, and I am bound to say that it immediately struck me as a fact not for me to digest, but for the champions of the North Sea ice-sheet to take to heart. Does Mr. Harker postulate a Norwegian ice-sheet in Cambridgeshire? else how does he account for these stones? That Cambridge and all the Fenland was not ravaged in every direction by the Vikings when the country round the Wash was virtually a lake *I do know*, and I need not draw the necessary inference. The sporadic character of the finds is surely a lesson in itself to be coupled with the admission made by Mr. Harker, that the stones about which we are discussing have not been found inland in Yorkshire, and only on the shore. If an ice-sheet or icebergs brought them, and others like them, to Cromer and Cambridge, how is this to be explained? Again, I would seriously ask if any human being who has seen ice at work, either in glaciers or icebergs, ever saw anything less like ice-moved stones than these rounded water-worn boulders? Ice carries a considerable part of its great stones intact and unweathered on its back from end to end without rolling or rubbing them, and then deposits them with the boulders made by its own streams in moraines or in detached blocks at its terminus and sides, and does not select one or two special points easily accessible to boats and ships, *and there only* leave a few choice specimens *of water-worn* stones mixed with a vastly greater proportion of stones which have confessedly come from the opposite direction!

I must repeat, in conclusion, that the question is too important to be settled by a few flippant sentences. My position is that on every ground, *a priori* and empirical, the evidence goes to show that it is impossible to attribute the transport of these stones to an ice-sheet or icebergs from Scandinavia, as Mr. Harker argued in his well-known Yorkshire Memoir, and as I presume from his ambiguous phrases he argues still. If he can suggest a more reasonable and simple explanation of the presence of these stones where they have been found than mine, I will gladly accept it. Hitherto he has failed to do so: hence these tears!

H. H. Howorth.